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| APPLICATION NUMBER | PATENT NUMBER | GROUP ART UNIT | FILE WRAPPER LOCATION |
|--------------------|---------------|----------------|-----------------------|
| 11/154,894         | 7179046       | 3745           | 9200                  |

## Correspondence Address / Fee Address Change

The following fields have been set to Customer Number 70382 on 12/12/2007

- Correspondence Address
- Maintenance Fee Address

**The address of record for Customer Number 70382 is:**

PATENTABILITY ASSOCIATES  
 P.O. BOX 9551  
 SAN JOSE, CA 95157

NOT AVAILABLE COPY

**AAON, Inc.****Worksheet**

1425 South Yukon Ave. Tulsa, Oklahoma 74107-3728 Ph. (918) 583-2266 Fax (918) 583-6094

AAONBcat32 Ver. 4.08 Bcat

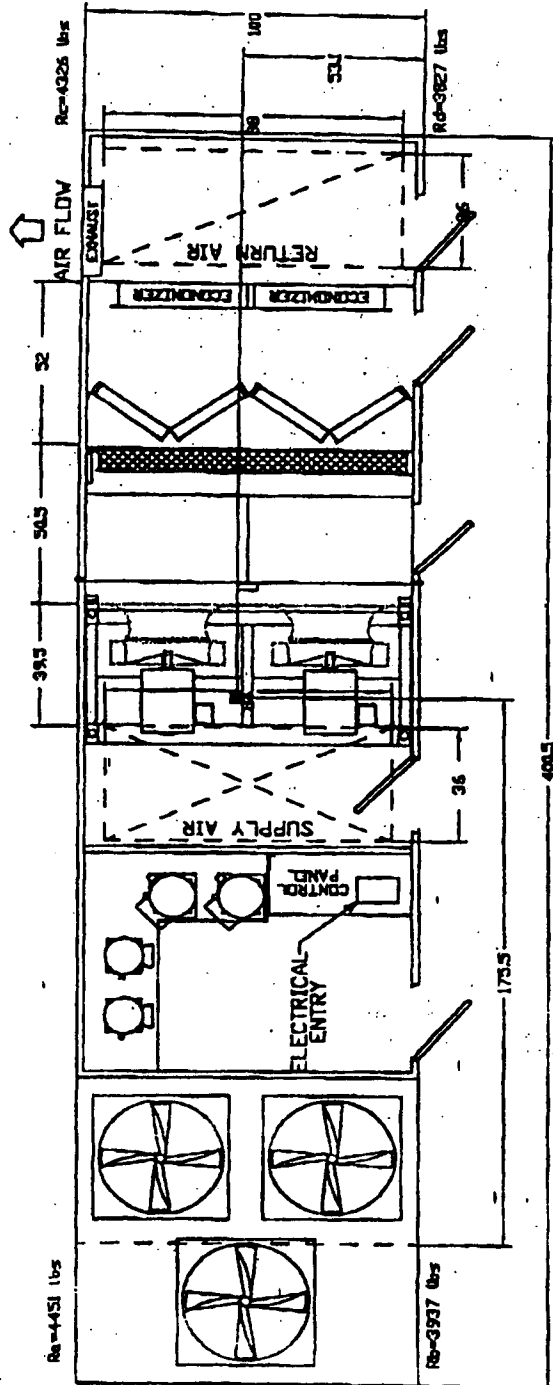
RL-075-3-0-AA04-000:A000-E00-JAZ-A0A-GA0ADB J-00-00000000X  
Tag: 3 WestJob Name:  
Job Number:Borders East Tower  
Job #2Worksheet Form  
Worksheet Date:Borders Group Inc.  
February 26, 2001

|     | Base Option           | Description                                | List Price | Rep. Price | Cust. Price |
|-----|-----------------------|--|------------|------------|-------------|
| R   | Series                | Roof Top Unit                              |            |            |             |
| L   | Generation            | Eight Generation                           |            |            |             |
| 075 | Size                  | Seventy Five                               |            |            |             |
| 3   | Voltage               | 460V/3Ø/60Hz                               |            |            |             |
| 0   | Interior Protection   | Standard                                   |            |            |             |
| A   | Cooling Style         | Draw Thru - R22 Dual Circuited Compressors |            |            |             |
| A   | Cooling Configuration | Air Cooled Cond w/ 4R Cgil High CFM        |            |            |             |
| 0   | Cooling Coating       | Std  |            |            |             |
| 4   | Cooling Stages        | 1 Stage                                    |            |            |             |
| 0   | Heating Type          | No Heat                                    |            |            |             |
| 0   | Heating Designation   | No Heat                                    |            |            |             |
| 0   | Heating Stages        | No Heat                                    |            |            |             |

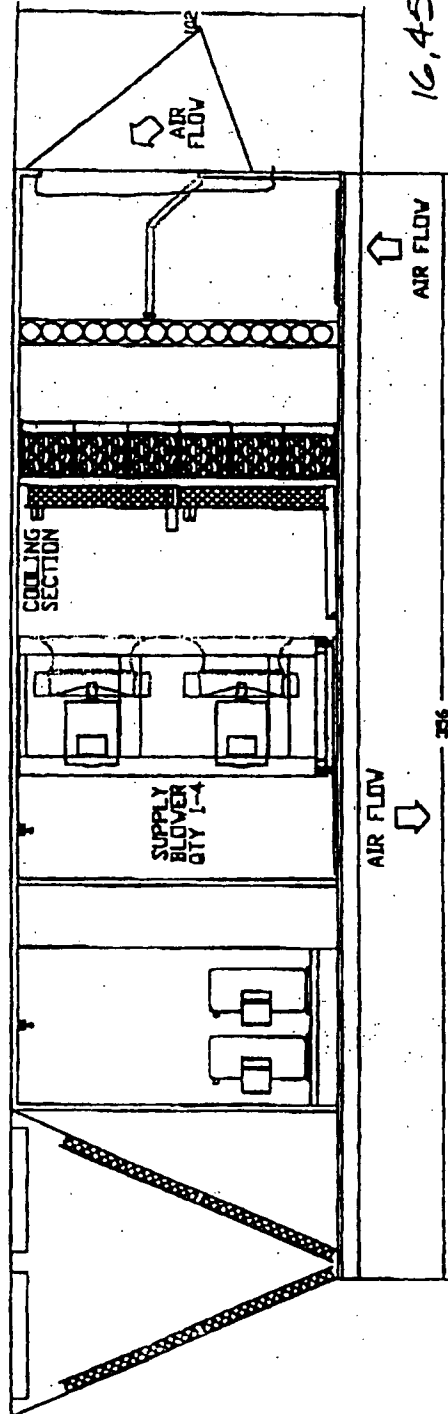
|   | Feature Option               | Description                                 | List Price | Rep. Price | Cust. Price |
|---|------------------------------|---|------------|------------|-------------|
| A | 1A. Outside Air Options      | Economizer                                  |            |            |             |
| 0 | 1B. RA Blower Configuration  | Std (No return or exhaust blower)           |            |            |             |
| 0 | 1C. RA Blower                | Std (No return or exhaust blower)           |            |            |             |
| 0 | 1D. RA Motor                 | Std (No Motor)                              |            |            |             |
| E | 2. Outside Air Controls      | DDC Econ Control                            |            |            |             |
| 0 | 3. Discharge Location        | Bottom Discharge                            |            |            |             |
| 0 | 4. Return Location           | Bottom Return                               |            |            |             |
| J | 5A. SA Blower Configuration  | 2 Blowers w/ (Prem off mtr) w/ 1-VFD        |            |            |             |
| A | 5B. SA Blower                | Blower A (27" Diameter)                     |            |            |             |
| Z | 5C. SA Motor                 | 20.0 hp (1760 rpm)                          |            |            |             |
| A | 6A. Pre-Filter               | 4" Pleated                                  |            |            |             |
| 0 | 6B. Final Filter             | Std   |            |            |             |
| A | 6C. Filter Options           | CPS Pre Filter                              |            |            |             |
| G | 7. Refrigeration Controls    | 6 MTDR On & Off - 115V Outlet Factory Wired |            |            |             |
| A | 8. Refrigeration Options     | Hot Gas Bypass Lead Stage (HGB)             |            |            |             |
| 0 | 9. Refrigeration Accessories | Std   |            |            |             |
| A | 10. Power Options            | 225 Amps Power Switch                       |            |            |             |
| D | 11. Safety options           | R/A & S/A Smoke Detector                    |            |            |             |
| B | 12. Controls                 | Phase & Brown Out Protection                |            |            |             |
| J | 13. Special Controls         | Factory Installed DDC Controls by Others    |            |            |             |
| 0 | 14A. Pre-Heat Configuration  | Std (No Preheat)                            |            |            |             |
| 0 | 14B. Pre-Heat Sizing         | Std (No Preheat)                            |            |            |             |
| 0 | 15. Option Boxes             | Std   |            |            |             |
| 0 | 16. Cabinet Options          | Std   |            |            |             |
| 0 | 17. Cabinet Options          | Std   |            |            |             |
| 0 | 18. Customer Code            | Std   |            |            |             |
| 0 | 19. Code Options             | Std ETL USA Listing                         |            |            |             |
| 0 | 20. Unit Splits              | Std (One Piece Unit)                        |            |            |             |
| 0 | 21. Evap & Water Condenser   | Std (No Evap or Water Condenser)            |            |            |             |
| 0 | 22. Blush                    | Std   |            |            |             |
| X | 23. Type                     | Special Price Authorization & Gray Paint    |            |            |             |
|   |                              | Subtotal                                    |            |            |             |
|   |                              | Quantity                                    |            |            |             |
|   |                              | Total                                       |            |            |             |

CL 548

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tone but 3/25/02



16,459 lbs

UNIT TAG 3 East & 3 West

Configuration RL-075-3-0-A004-000A000-ED0-JAZ-40A-GAGADBJ-00-00000000

JOB NAME Borders Court Tower

DATE 02/06/2001

SERIAL NO.

PURCHASE ORDER

PURCHASER

Total Weight 16541 / Shipping Weight 16541

Rep Contact

Ordered By

Engineer

AAON inc.

TULSA OKLAHOMA

CL 549

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SHIP ON 1/8/99

AAON, Inc.

2425 S. Yukon • Tulsa, OK 74107 • Ph: (918) 583-2266 • Fax: (918) 583-6094

DATE: 9/15/98 PAGE 7 of 7 Order Form

|               |                            |
|---------------|----------------------------|
| SOLD TO       | BOVI'S CONSTRUCTION CORP   |
|               | PRINCETON FORESTAL VILLAGE |
| SHIP TO       | 100-200 VILLAGE BLVD.      |
|               | PRINCETON, N.J. 08540      |
| (WILL ADVISE) |                            |

|   |   |
|---|---|
| CUSTOMER P.O. No.                           | JOB No.   |
| JOB NAME: THE COMMONS                       |   |
| CUSTOMER NO.                                | AAON CONTACT: J. BARNER   |
| SHOP ORDER No. 194639                       | CUST. CONTACT: K. GADINER   |
| REP. #1 757                                 | REP. #2   |
| SHIPPING INFORMATION                        |   |
| REQ. SHIP DATE:                             | HOLD FOR APPROVAL <input type="checkbox"/> RELEASE TO PRODUCTION <input type="checkbox"/> |
| SHIP VIA: FNT ALLOWED                       |   |
| ALLOWED <input checked="" type="checkbox"/> | PPD & ADD ACTUAL <input type="checkbox"/> COLLECT <input type="checkbox"/>                |
| NOTIFY: RICK                                |   |
| 48 HOURS BEFORE DELIVERY                    | PHONE No. 609/419-1380  |

| QTY      | PART NO.   | DESCRIPTION   | UNIT | EXT. |
|----------|--|---|------|------|
| 6        | R1F1R2-3-FD-IDL: N1 L1 L1 J1 Q1 D1 G1 Q1 J1 Q1 I1 Q1 I1 A1 X | CFM ESP NOISE: (1) TAG# 1A 2A 3A 4A 1B 2B   |      |      |
| TAG RTU: |  | (3) 46,500 CFM @ 2.75 ESP (3) 9EE NOISE   |      |      |
|          |  | (14) 7.5 HP VFD ON PROP EXHAUST   |      |      |
|          | R1   | CFM ESP (5) WINE ALL ANALOGUE   |      |      |
| TAG RTU: |  | SIGNALS TO LVTB (6) LEAVE 12 INCH X 12 INCH AREA IN CONTROL BOX FOR FIELD CONTROL |      |      |
| 2        | R1F1R2-3-FD-IDL: N1 L1 L1 J1 Q1 D1 G1 Q1 J1 Q1 I1 Q1 I1 A1 X | CFM ESP NOISE: (1) TAG# 5A 5B (2) 46,500 CFM                                      |      |      |
| TAG RTU: |  | (2) 2.75 ESP (3) 9EE NOISE (4) WINE ALL ANALOGUE SIGNALS TO LVTB (5) LEAVE        |      |      |
|          | R1   | CFM ESP 12 INCH X 12 INCH AREA IN CONTROL   |      |      |
| TAG RTU: |  | BOX FOR FIELD CONTROLLER  |      |      |
|          | R1   | CFM ESP   |      |      |
| TAG RTU: |  |   |      |      |

1,200 FT PU1980

M/C

NOTE: (1) SPECIAL EVAP COILS (SEE 90A)  
 (2) PERFORATED LINERS IN SUPPLY AIR  
 (3) INSTALL CUSTOMER FURNISHED  
 TEMP SENSORS - Q1A - R1A - MIXED AIR  
 (4) PER NORM SHIP BY 1/8/98

(5) FURNISH & Multiplier 1.25 TOTAL NET (Rep. Cost) \$ 16,000.00  
 INSTALL DP SWITCH  
 FREIGHT \$  
 COMMISSION \$  
 FOR SUPPLY FAN STATUS  
 TOTAL BILLING \$  
 (6) FURNISH & INSTALL ISOLATION

NO PO ON PO# REL 550

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10/01/1998 08:12 7329810939

GIL BAR SALES

PAGE 02

**AAON, Inc.**

Tulsa, Oklahoma • Ph: (918) 583-2266 • Fax: (918) 583-6094

**Estimating Worksheet**DATE: REVISION 9/30/98 PAGE 2 of 9

NOTE: THIS WORKSHEET IS FOR ESTIMATING PURPOSES ONLY AND IS NOT INTENDED FOR ORDER PROCESSING.

MARK • RTU No. 1A...MARK • RTU No. 5A...

MARK • RTU No. \_\_\_\_\_

MARK • RTU No. \_\_\_\_\_

|                          |                    |            |
|--------------------------|--------------------|------------|
| MODEL                    | R                  | SERIES     |
|                          | F                  |            |
|                          | 110                | UNIT SIZE  |
|                          | 3                  | VOLTAGE    |
| NUMBER                   | E0                 | COOLING    |
|                          | BASE UNIT PRICE \$ |            |
|                          | 101                | HEATING    |
|                          | HEATING PRICE \$   |            |
| FEATURE                  | OPTION             | LIST PRICE |
|                          | N                  |            |
|                          | L                  |            |
|                          | L                  |            |
|                          | J                  |            |
|                          | O                  |            |
|                          | H                  |            |
|                          | G                  |            |
|                          | A                  |            |
|                          | J                  |            |
|                          | Ø                  |            |
|                          | O                  |            |
|                          | O                  |            |
|                          | A                  |            |
| B                        |                    |            |
| TOTAL UNIT LIST PRICE \$ |                    |            |
| KD \$                    |                    |            |
| SB \$                    |                    |            |

|                          |                    |            |
|--------------------------|--------------------|------------|
| MODEL                    | R                  | SERIES     |
|                          | F                  |            |
|                          | 120                | UNIT SIZE  |
|                          | 3                  | VOLTAGE    |
| NUMBER                   | F0                 | COOLING    |
|                          | BASE UNIT PRICE \$ |            |
|                          | 101                | HEATING    |
|                          | HEATING PRICE \$   |            |
| FEATURE                  | OPTION             | LIST PRICE |
|                          | N                  |            |
|                          | L                  |            |
|                          | L                  |            |
|                          | J                  |            |
|                          | O                  |            |
|                          | H                  |            |
|                          | G                  |            |
|                          | A                  |            |
|                          | J                  |            |
|                          | Ø                  |            |
|                          | O                  |            |
|                          | O                  |            |
|                          | A                  |            |
| B                        |                    |            |
| TOTAL UNIT LIST PRICE \$ |                    |            |
| KD \$                    |                    |            |
| SB \$                    |                    |            |

|                          |                    |            |
|--------------------------|--------------------|------------|
| MODEL                    | R                  | SERIES     |
|                          |                    |            |
|                          |                    | UNIT SIZE  |
|                          |                    | VOLTAGE    |
| NUMBER                   |                    | COOLING    |
|                          | BASE UNIT PRICE \$ |            |
|                          |                    | HEATING    |
|                          | HEATING PRICE \$   |            |
| FEATURE                  | OPTION             | LIST PRICE |
|                          |                    |            |
|                          |                    |            |
|                          |                    |            |
|                          |                    |            |
|                          |                    |            |
|                          |                    |            |
|                          |                    |            |
|                          |                    |            |
|                          |                    |            |
|                          |                    |            |
|                          |                    |            |
|                          |                    |            |
|                          |                    |            |
| TOTAL UNIT LIST PRICE \$ |                    |            |
| KD \$                    |                    |            |
| SB \$                    |                    |            |

|                          |                    |            |
|--------------------------|--------------------|------------|
| MODEL                    | R                  | SERIES     |
|                          |                    |            |
|                          |                    | UNIT SIZE  |
|                          |                    | VOLTAGE    |
| NUMBER                   |                    | COOLING    |
|                          | BASE UNIT PRICE \$ |            |
|                          |                    | HEATING    |
|                          | HEATING PRICE \$   |            |
| FEATURE                  | OPTION             | LIST PRICE |
|                          |                    |            |
|                          |                    |            |
|                          |                    |            |
|                          |                    |            |
|                          |                    |            |
|                          |                    |            |
|                          |                    |            |
|                          |                    |            |
|                          |                    |            |
|                          |                    |            |
|                          |                    |            |
|                          |                    |            |
|                          |                    |            |
| TOTAL UNIT LIST PRICE \$ |                    |            |
| KD \$                    |                    |            |
| SB \$                    |                    |            |

A 6/14 91.25 DX COIL

6/14 91.25 DX COIL

INCL.

C PERF LINERS-SUPPLY

PERF. LINER-SUPPLY

#3600

MOUNT DDC

MOUNT DDC

1450

S 49" SUPPLY FAN

---

750 (RTU - 1A... ONLY)

S EXH. VFD - 7.5HP

EXH. VFD - 7.5HP

2750

LIST PRICE  
EA 36LIST PRICE  
EA 36LIST PRICE  
EALIST PRICE  
EA

10/01/1998 08:12 7329810939

GIL BAR SALES

PAGE 07

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AAON, INC.  
2425 South Yukon  
Tulsa, Oklahoma 74107  
Phone: (918) 583-3266  
Fax: (918) 583-6094

**AAON, INC.**

**FAX**

TO: Kevin Gabinelli  
Gil-Bar

FROM: Natalie Neilson

DATE: 6-30-98

FAX NO: 732-981-0939

PAGES: 1

SUBJECT: RF-130 Special Pricing - SPA#89008

Kevin,

To provide the RF-150 with perforated liners on the supply section is \$3,600 list add. ←  
~~To provide the RF-150 with perforated liners on the return section is \$3,100 list add.~~

I do not have the pricing for the entire unit, so I will have to research this and get back with you.

Also, I don't know what to tell you on the "Sharing 7" job, you really need to discuss this matter with Steve pagetter. Sorry!!!!

*This pricing is valid for use within 30 days of this transmission. Please send in a copy of this letter or the SPA number to expedite the process.*

Thank you,

Natalie Neilson  
Ext. 293

CL 552

BM03L5 AC AON, INC. WIRING DIAGRAM ASSIGNMENT  
& VERIFICATION

01 Apr 2002 PAGE 1

REQUESTED BY ccox-eng /dev/pts/29

REQUISITION NUMBER: 256816

ORDER INFORMATION

CUSTOMER: FREY LUTZ CORPORATION  
SHIP-TO : HARRISBURG, PA 17110  
JOB NAME: FARM SHOW ARENA

LEAD DTE: 12/27/01 SHIP ON : 06/30/02

CONTACT : B. SMITH

| SEQ | PART NBR | QTY | DESCRIPTION  | DISPOSITION                |
|-----|----------|-----|--|----------------------------|
| 001 | @        | 0   | RL-135-3-0-F20Q-344:<br>A000E00KB2CP0D00A00J0000GB00000X | --no-ENG                   |
| 002 | @        | 9   | RL-230-3-0-0F08-354:<br>BGBE00DKELCP0DACE00J0000GR000A0X | EEfrnt 04/01/02 by CCOX-EN |
| 003 | @FREIGHT | 1   |  | --no-ENG                   |
| 004 | @REP-780 | 1   |  | --no-ENG                   |

Sales and Engineering text lines for entire order

-----SALES HEADER INFO-----

NOTE ON JOB SAYS "HOLD FOR  
APPROVAL" (WRITTEN BY JIM  
PARRO)

REVISED OPTION #15 FROM [0] TO  
[A] PER J. PARRO 1/4/02 DS  
3/5 PER BRETT S.-SHIP APPROX.  
6/30. JL

PER BUCK NYE SHIP UNITS END OF  
JUNE IF POSSIBLE!!!

-----ENG HEADER INFO-----

-----SALES LINE ITEM # 001-----

- 1] 38000 CFM @ 1.5 ESP
- 2] SUPPLY FAN BACK DRAFT  
DAMPER
- 3] SPA #101255
- 4] TAG #1

-----SALES LINE ITEM # 002-----

- 1] 42500 CFM @ 2.25 ESP
- 2] SUPPLY FAN BACK DRAFT  
DAMPER
- 3] RA FAN PITCH 40"
- 4] TAG #1 THRU 9
- 5] SPA #101255
- 6] 8 ROW DX COILS
- 7] (4) COPELAND SCREW  
COMPRESSORS
- 8] STAINLESS STEEL CONDENSER  
FAN MOTOR SHAFT
- 9] 14 GA. BASE SHEETS
- 10] BURGLAR BARS ON 3" CENTERS
- 11] FACTORY INSTALL CUSTOMER  
PROVIDED CONTROLS
- 12] MAKE-UP WATER BACKFLOW  
PREVENTER

*RL230*  
*Looking (4) screw / Eng could use*  
*GAS Heat (12 Stg (10 Tubes)*  
*2 Power Exhaust w/ 2 VFD S*  
*DPC Eco —*  
*2 Supply Fans w/ 2 VFD S*  
*Maintenance Lights.*

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Feb. 26, 2002, 10:53AM

JACCO &amp; ASSOCIATES

NO. 9062 P. 7

**AAON, Inc.****Worksheet**

2425 South Yukon Ave - Tulsa, Oklahoma 74107-2725 - Ph. (918) 583-2266 Fax (918) 583-6094

AAONBcat32 Ver. 4.08 Beta

RL-075-8-0-0B04-000:BCBD-DAF-EAE-000-G00B000-00-00000000B

Tag: RTU# 1

Job Name:  
Job Number:HARRISON HILLS  
Job #1Worksheet For:  
Worksheet Date:Jacco Associates  
February 26, 2002

|     | Base Option           | Description                              | List Price | Rep. Price | Cust. Price |
|-----|-----------------------|--|------------|------------|-------------|
| R   | Series                | Roof Top Unit                            |            |            |             |
| L   | Generation            | Eight Generation                         |            |            |             |
| 075 | Size                  | Seventy Five                             |            |            |             |
| 8   | Voltage               | 208V/3Ø/60Hz                             |            |            |             |
| 0   | Interior Protection   | Standard                                 |            |            |             |
| 0   | Cooling Style         | Blow Thru - R22 Dual Circuit Compressors |            |            |             |
| B   | Cooling Configuration | Air Cooled Cond w/ 6R Coil High CFM      |            |            |             |
| 0   | Cooling Coating       | Std                                      |            |            |             |
| 4   | Cooling Stages        | 4 Stage                                  |            |            |             |
| 0   | Heating Type          | No Heat                                  |            |            |             |
| 0   | Heating Designation   | No Heat                                  |            |            |             |
| 0   | Heating Stages        | No Heat                                  |            |            |             |

|   | Feature Option               | Description                                 | List Price | Rep. Price | Cust. Price |
|---|------------------------------|---|------------|------------|-------------|
| B | 1A. Outside Air Options      | Power Exhaust                               |            |            |             |
| C | 1B. RA Blower Configuration  | 1 Blower (From eX mtr)                      |            |            |             |
| B | 1C. RA Blower                | Blower B (42" Dia 9 Blade)                  |            |            |             |
| D | 1D. RA Motor                 | 3.0 hp (1170 rpm)                           |            |            |             |
| D | 2. Outside Air Controls      | Full Mod Enthalpy Econ                      |            |            |             |
| A | 3. Discharge Location        | Front Discharge                             |            |            |             |
| F | 4. Return Location           | Front Return High CFM (w/ arc or pwr ex)    |            |            |             |
| E | 5A. SA Blower Configuration  | 2 Blowers w/(From eX mtr)                   |            |            |             |
| A | 5B. SA Blower                | Blower A (27" Diameter)                     |            |            |             |
| E | 5C. SA Motor                 | 3.0 hp (1170 rpm)                           |            |            |             |
| 0 | 6A. Pre-Filter               | 3" Pleated                                  |            |            |             |
| 0 | 6B. Final Filter             | Std   |            |            |             |
| 0 | 6C. Filter Options           | Std   |            |            |             |
| G | 7. Refrigeration Controls    | 5 MTDR On & Off - 115V Outlet Factory Wired |            |            |             |
| 0 | 8. Refrigeration Options     | Std   |            |            |             |
| 0 | 9. Refrigeration Accessories | Std   |            |            |             |
| B | 10. Power Options            | 400 Amps Power Switch                       |            |            |             |
| 0 | 11. Safety options           | Std   |            |            |             |
| 0 | 12. Controls                 | Std   |            |            |             |
| 0 | 13. Special Controls         | Std   |            |            |             |
| 0 | 14A. Pre-Heat Configuration  | Std (No Preheat)                            |            |            |             |
| 0 | 14B. Pre-Heat Sizing         | Std (No Preheat)                            |            |            |             |
| 0 | 15. Option Boxes             | Std   |            |            |             |
| 0 | 16. Cabinet Options          | Std   |            |            |             |
| 0 | 17. Cabinet Options          | Std   |            |            |             |
| 0 | 18. Customer Code            | Std   |            |            |             |
| 0 | 19. Code Options             | Std ETL-USA Listing                         |            |            |             |
| 0 | 20. Unit Splits              | Std (One Piece Unit)                        |            |            |             |
| 0 | 21. Evap & Water Condenser   | Std (No Evap or Water Condenser)            |            |            |             |
| 0 | 22. Blank                    | Std   |            |            |             |
| B | 23. Type                     | Std (Includes 'Grav Paint')                 |            |            |             |
|   |                              | Subtotal                                    |            |            |             |
|   |                              | Quantity                                    |            |            |             |
|   |                              | Total                                       |            |            |             |

CL 554



TULSA OKLAHOMA

Total Weight: 16937 / Shipping Weight: 16937

Config 1: RL-075-8-0-BRD-0-MD-ED-D-DAF-EAC-080-G08 M08-08-00000008

**PURCHASER** JACO ASSOCIATES

Rep Control'

PURCHASE ORDER 02009/\*db

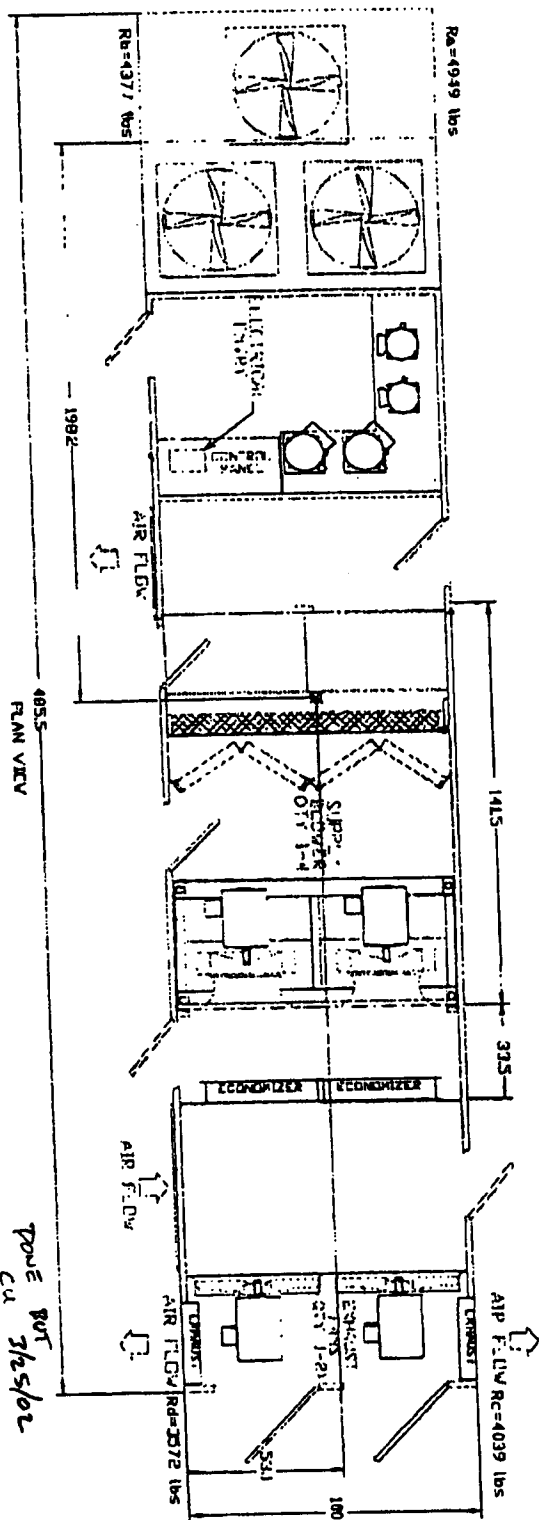
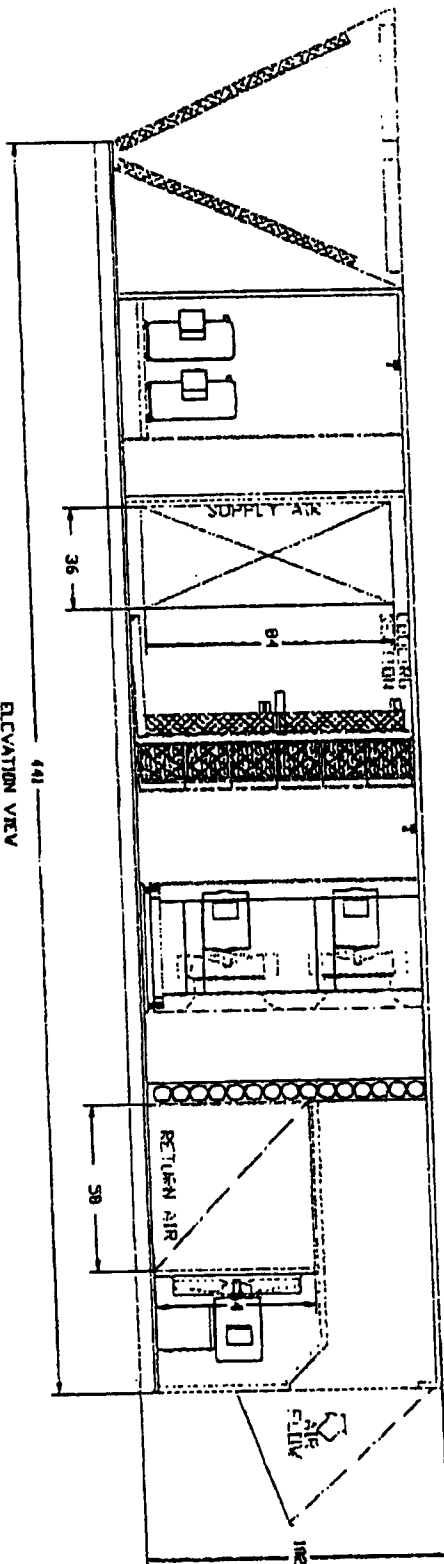
Ordered By: W.D Brown

**SERIAL NO.**

DATE: 02/26/2002

UNIT TAG RETURN :

**ELEVATION VIEW**



POW <sup>BT</sup>  
CU 3/25/02

# ~~CL 555~~

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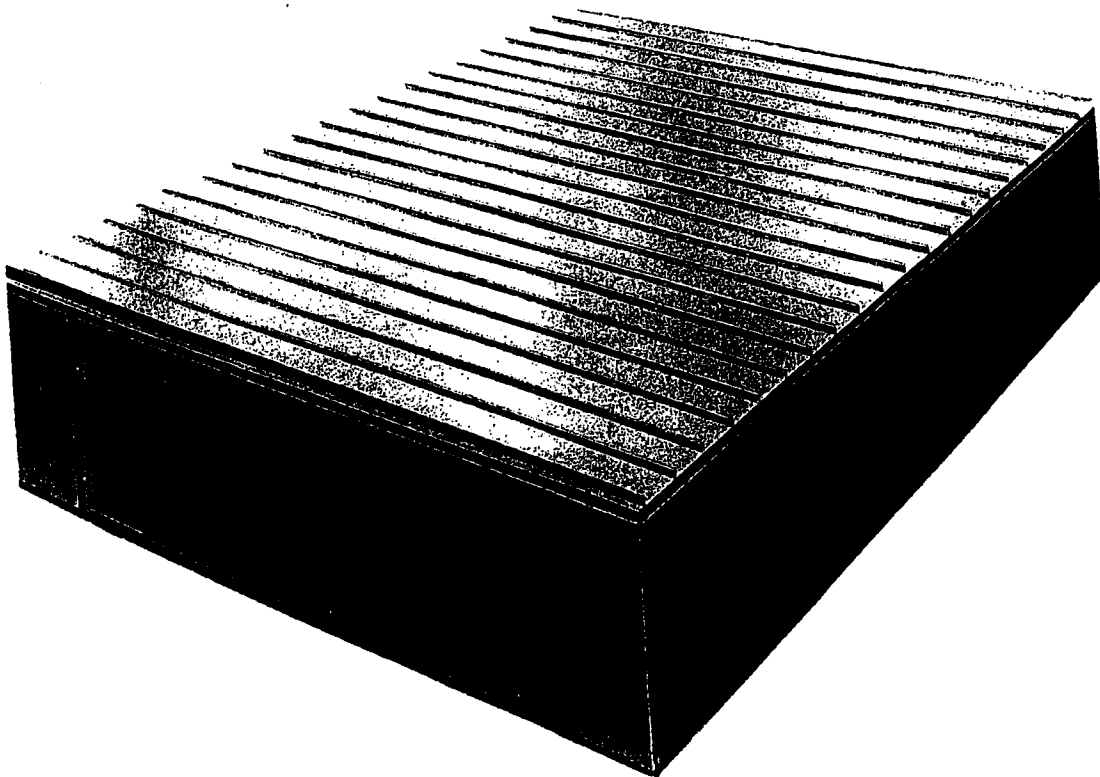
| B. FEATURE MASTER - FEATURE NUMBER<br>UPDATED WITHIN: |   | C. FEATURE - SPECIAL LOCATIONS |   | D. FEATURE - SPECIAL LOCATIONS |   | E. FEATURE - SPECIAL LOCATIONS |   | F. FEATURE - SPECIAL LOCATIONS |    | G. FEATURE - SPECIAL LOCATIONS |    | H. FEATURE - SPECIAL LOCATIONS |    | I. FEATURE - SPECIAL LOCATIONS |    | J. FEATURE - SPECIAL LOCATIONS |    | K. FEATURE - SPECIAL LOCATIONS |    | L. FEATURE - SPECIAL LOCATIONS |    | M. FEATURE - SPECIAL LOCATIONS |    | N. FEATURE - SPECIAL LOCATIONS |    | O. FEATURE - SPECIAL LOCATIONS |    | P. FEATURE - SPECIAL LOCATIONS |    | Q. FEATURE - SPECIAL LOCATIONS |    | R. FEATURE - SPECIAL LOCATIONS |    | S. FEATURE - SPECIAL LOCATIONS |    | T. FEATURE - SPECIAL LOCATIONS |    | U. FEATURE - SPECIAL LOCATIONS |    | V. FEATURE - SPECIAL LOCATIONS |    | W. FEATURE - SPECIAL LOCATIONS |    | X. FEATURE - SPECIAL LOCATIONS |    | Y. FEATURE - SPECIAL LOCATIONS |    | Z. FEATURE - SPECIAL LOCATIONS |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |     |
|---|---|--------------------------------|---|--------------------------------|---|--------------------------------|---|--------------------------------|----|--------------------------------|----|--------------------------------|----|--------------------------------|----|--------------------------------|----|--------------------------------|----|--------------------------------|----|--------------------------------|----|--------------------------------|----|--------------------------------|----|--------------------------------|----|--------------------------------|----|--------------------------------|----|--------------------------------|----|--------------------------------|----|--------------------------------|----|--------------------------------|----|--------------------------------|----|--------------------------------|----|--------------------------------|----|--------------------------------|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|-----|
| 1   | 2 | 3                              | 4 | 5                              | 6 | 7                              | 8 | 9                              | 10 | 11                             | 12 | 13                             | 14 | 15                             | 16 | 17                             | 18 | 19                             | 20 | 21                             | 22 | 23                             | 24 | 25                             | 26 | 27                             | 28 | 29                             | 30 | 31                             | 32 | 33                             | 34 | 35                             | 36 | 37                             | 38 | 39                             | 40 | 41                             | 42 | 43                             | 44 | 45                             | 46 | 47                             | 48 | 49                             | 50 | 51 | 52 | 53 | 54 | 55 | 56 | 57 | 58 | 59 | 60 | 61 | 62 | 63 | 64 | 65 | 66 | 67 | 68 | 69 | 70 | 71 | 72 | 73 | 74 | 75 | 76 | 77 | 78 | 79 | 80 | 81 | 82 | 83 | 84 | 85 | 86 | 87 | 88 | 89 | 90 | 91 | 92 | 93 | 94 | 95 | 96 | 97 | 98 | 99 | 100 |

CL 556

BEST AVAILABLE COPY

# Custom Penthouse

200 – 410 Tons  
Cooling-only VAV configurations



*Selection Guide*

CL 557

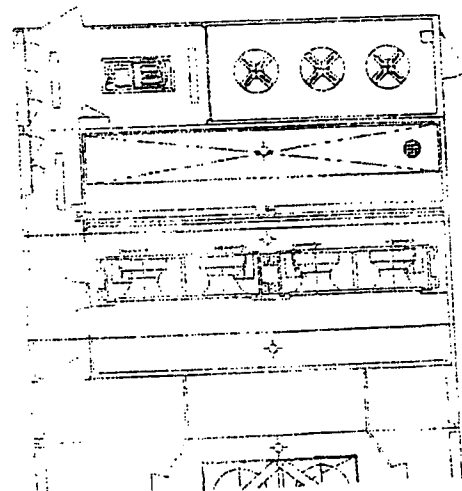
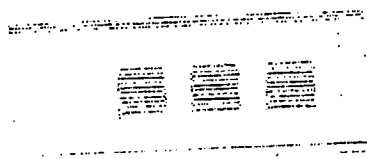
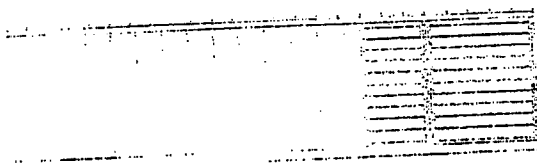
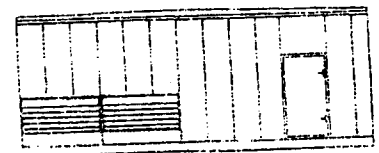
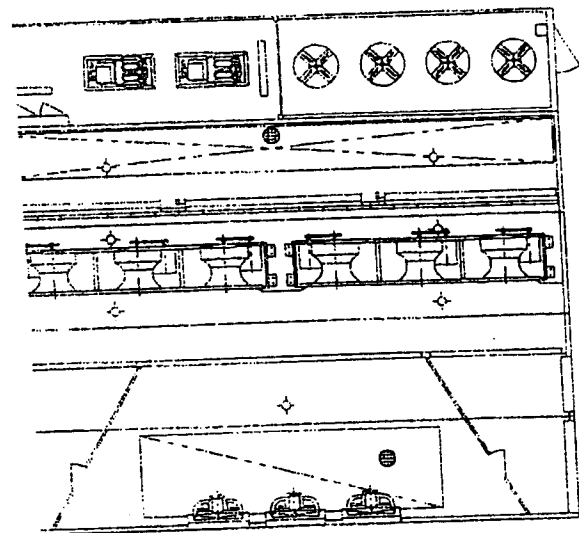
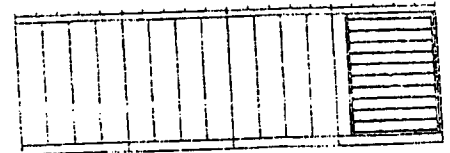
## **Look into a Mammoth Custom Penthouse for flexibility, efficiency, and reliability**

For your next HVAC design, take advantage of lower first costs, shorter construction cycles and time-proven performance. Enjoy complete system flexibility, without the design, procurement and labor costs normally associated with field-built systems.

### ***Specify a Mammoth Custom Penthouse***

Mammoth has engineered the Custom Penthouse to meet the conditioning needs of office buildings, retail establishments and warehouse/industrial facilities with cooling requirements from 200 to 600 tons.

The following data provides an overview of Custom Penthouse configurations and performance characteristics available for variable air volume (VAV), cooling-only applications. If your project requires additional capacity or mechanical equipment, the Custom Penthouse can be engineered to satisfy those requisites. After all, the number of possible options ends only when you are satisfied.



## ***Custom Penthouse standard features***

- ☐ Evaporative condenser with staging/unloading capability
- ☐ York semi-hermetic reciprocating compressors
- ☐ Supply and return fan staging
- ☐ DX cooling and fan redundancy
- ☐ Custom exterior color (air dry)
- ☐ Walk-in service vestibule
- ☐ Full interior service lighting
- ☐ Factory-wired 15-amp GFI convenience outlet
- ☐ Remote unit status monitoring panel
- ☐ Vari-Cone® air modulator
- ☐ Four-inch 30% efficiency filters
- ☐ Low-leakage outside/return air dampers
- ☐ Full economizer control
- ☐ Water treatment interface for condenser
- ☐ Single point main and temperature control
- ☐ Factory certified start-up
- ☐ ETL labeled

## ***Optional features***

- ☐ Screw compressors
- ☐ Factory fabricated, field installed curbing
- ☐ Direct digital control (DDC) interface or complete DDC unit controls
- ☐ Acoustical inner liner panels
- ☐ Access stairways
- ☐ Custom-sized DX coils and supply air openings (requires factory confirmation)
- ☐ Fire and smoke sequence of operation
- ☐ Custom remote control panel
- ☐ Factory-certified final field piping/electrical connections

This is just a sampling of options available for the Mammoth Custom Penthouse. For more information, consult your Mammoth Representative.

## UNIT PHYSICAL AND NOMINAL PERFORMANCE DATA

| MODEL                                    | Propeller Exhaust |               |               |               |               |               | Power Return |               |               |               |               |               |
|--|-------------------|---------------|---------------|---------------|---------------|---------------|--------------|---------------|---------------|---------------|---------------|---------------|
|  | 2102              | 2602          | 3002          | 3502          | 4203          | 4403          | 2102         | 2602          | 3002          | 3502          | 4203          | 4403          |
| Condenser KW                             | 164.7             | 199.8         | 225.0         | 275.5         | 315.0         | 340.4         | 164.7        | 199.8         | 225.0         | 275.5         | 315.0         | 340.4         |
| Unit Total Full Load Amps (460/3/60)     | 427.0             | 555.2         | 591.6         | 777.8         | 856.0         | 890.0         | 474.0        | 579.2         | 627.6         | 803.8         | 892.0         | 944.0         |
| DX Cooling Capacity MBH/Tons Total       | 2400/200          | 2940/245      | 3300/275      | 3960/330      | 4560/380      | 4920/410      | 2400/200     | 2940/245      | 3300/275      | 3960/330      | 4560/380      | 4920/410      |
| Sensible                                 | 1825/152          | 2215/184      | 2485/207      | 2985/248      | 3405/283      | 3740/311      | 1825/152     | 2215/184      | 2485/207      | 2985/248      | 3405/283      | 3740/311      |
| DX Coil Rows/Fins per Inch               | 5/10              | 5/10          | 5/10          | 5/10          | 5/10          | 5/10          | 5/10         | 5/10          | 5/10          | 5/10          | 5/10          | 5/10          |
| Square Feet                              | 132               | 157           | 177           | 211           | 241           | 271           | 132          | 157           | 177           | 211           | 241           | 271           |
| Main Supply Fan Data                     |                   |               |               |               |               |               |              |               |               |               |               |               |
| Supply Air CFM                           | 76,000            | 93,100        | 104,500       | 125,400       | 144,400       | 155,800       | 76,000       | 93,100        | 104,500       | 125,400       | 144,400       | 155,800       |
| Supply Air TSP ("WC)                     | 5.0               | 5.0           | 5.0           | 5.0           | 5.0           | 5.0           | 5.0          | 5.0           | 5.0           | 5.0           | 5.0           | 5.0           |
| Supply Air Brake HP/ Actual HP           | 112/120           | 128/160       | 148/160       | 171/240       | 204/240       | 222/240       | 112/120      | 128/160       | 148/160       | 171/240       | 204/240       | 222/240       |
| Power Return Air/ Exhaust Air Fan Data   |                   |               |               |               |               |               |              |               |               |               |               |               |
| Return Air CFM                           | N/A               | N/A           | N/A           | N/A           | N/A           | N/A           | 68,400       | 83,700        | 94,000        | 112,800       | 129,000       | 140,200       |
| Return Air ESP ("WC)                     | N/A               | N/A           | N/A           | N/A           | N/A           | N/A           | 1.5          | 1.5           | 1.5           | 1.5           | 1.5           | 1.5           |
| Return Air Brake HP/ Actual HP           | N/A               | N/A           | N/A           | N/A           | N/A           | N/A           | 58/60        | 45/50         | 55/60         | 57/60         | 72/75         | 83/90         |
| Prop Exhaust Fan Data                    |                   |               |               |               |               |               |              |               |               |               |               |               |
| Exhaust Air CFM                          | 68,400            | 83,700        | 94,000        | 112,800       | 129,000       | 140,200       | N/A          | N/A           | N/A           | N/A           | N/A           | N/A           |
| Exhaust Air ESP ("WC)                    | 0.50              | 0.50          | 0.50          | 0.50          | 0.50          | 0.50          | N/A          | N/A           | N/A           | N/A           | N/A           | N/A           |
| Actual HP                                | 22.5              | 30.0          | 30.0          | 37.5          | 45.0          | 45.0          | N/A          | N/A           | N/A           | N/A           | N/A           | N/A           |
| Filters (4")                             |                   |               |               |               |               |               |              |               |               |               |               |               |
| 35% Eff. - Square Feet                   | 167.0             | 208.0         | 208.0         | 267.0         | 267.0         | 333.0         | 167.0        | 208.0         | 208.0         | 267.0         | 267.0         | 333.0         |
| Louver/Damper Data                       |                   |               |               |               |               |               |              |               |               |               |               |               |
| Outside Air Louver-Sq. Ft.               | 104.0             | 184.0         | 184.0         | 184.0         | 184.0         | 184.0         | 104.0        | 184.0         | 184.0         | 184.0         | 184.0         | 184.0         |
| Outside Air Motorized Damper-Sq. Ft.     | 68.0              | 93.0          | 93.0          | 160.0         | 160.0         | 160.0         | 68.0         | 93.0          | 93.0          | 160.0         | 160.0         | 160.0         |
| Return Air Motorized Damper-Sq. Ft.      | 86.0              | 103.0         | 103.0         | 163.0         | 163.0         | 163.0         | 86.0         | 103.0         | 103.0         | 163.0         | 163.0         | 163.0         |
| Exhaust Air Non-Motorized Damper-Sq. Ft. | 52.0              | 69.0          | 69.0          | 86.0          | 104.0         | 104.0         | 68.0         | 75.0          | 75.0          | 101.0         | 101.0         | 101.0         |
| Size - Length x Width                    | 30' x 25'         | 37 1/2' x 30' | 37 1/2' x 30' | 37 1/2' x 45' | 37 1/2' x 45' | 37 1/2' x 45' | 30' x 25'    | 37 1/2' x 30' | 37 1/2' x 30' | 37 1/2' x 45' | 37 1/2' x 45' | 37 1/2' x 45' |
| Operating Weight (lbs.)                  | 43,967            | 59,352        | 59,880        | 80,216        | 83,208        | 84,057        | 44,924       | 60,405        | 61,033        | 81,935        | 84,742        | 85,591        |

## DESIGN CRITERIA

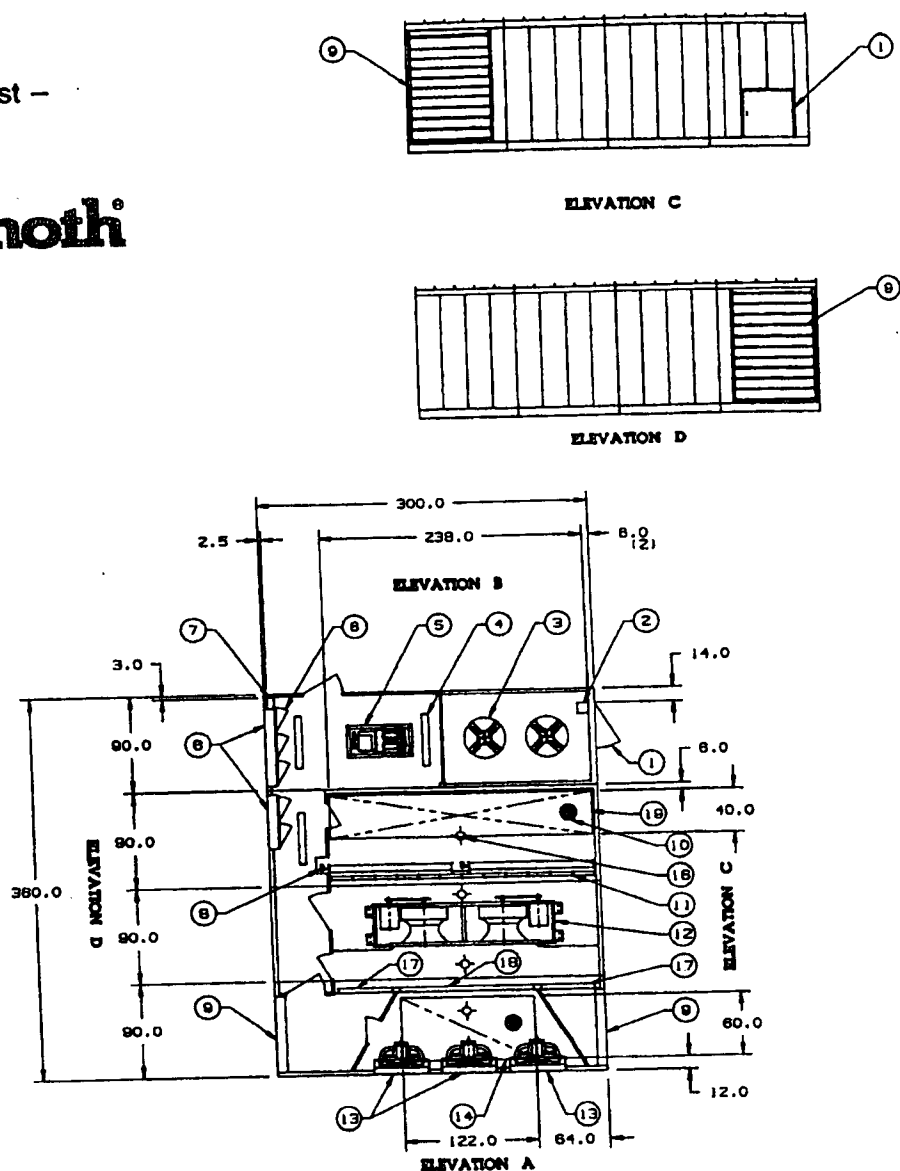
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- 2) Cooling loads based on 80°/67°F entering air temperature to DX cooling coil.
- 3) DX cooling capacity based on DX saturated suction temperature of 45°F and 78°F entering wet bulb design temperature.
- 4) All data based upon a Custom Penthouse unit height of 10 feet 4 inches only.
- 5) For smaller/larger capacity units, please consult your Mammoth representative.



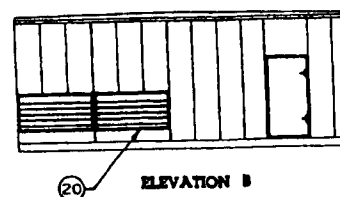
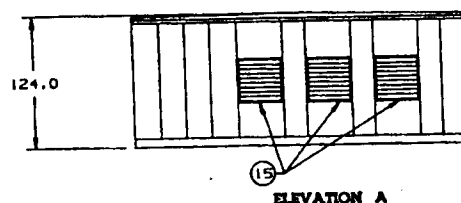
**REFERENCE**

Propeller Exhaust –  
Model 2102

# Mammoth®



| ITEM | DESCRIPTION                            |
|------|--|
| 1    | Sump access                            |
| 2    | 10" x 10" Supply and drain water chase |
| 3    | Condenser fans                         |
| 4    | Fluorescent lights                     |
| 5    | Compressors                            |
| 6    | Control box                            |
| 7    | 6" x 12" Electrical chase              |
| 8    | Evaporator coils                       |
| 9    | Outside air louvers                    |
| 10   | Bar grate                              |
| 11   | 4" filters                             |
| 12   | Main supply fans                       |
| 13   | Prop exhaust fans                      |
| 14   | Return opening                         |
| 15   | Exhaust louvers                        |
| 16   | Incandescent vapor proof lights        |
| 17   | Outside air dampers                    |
| 18   | Return air dampers                     |
| 19   | Supply opening                         |
| 20   | Sump intake                            |

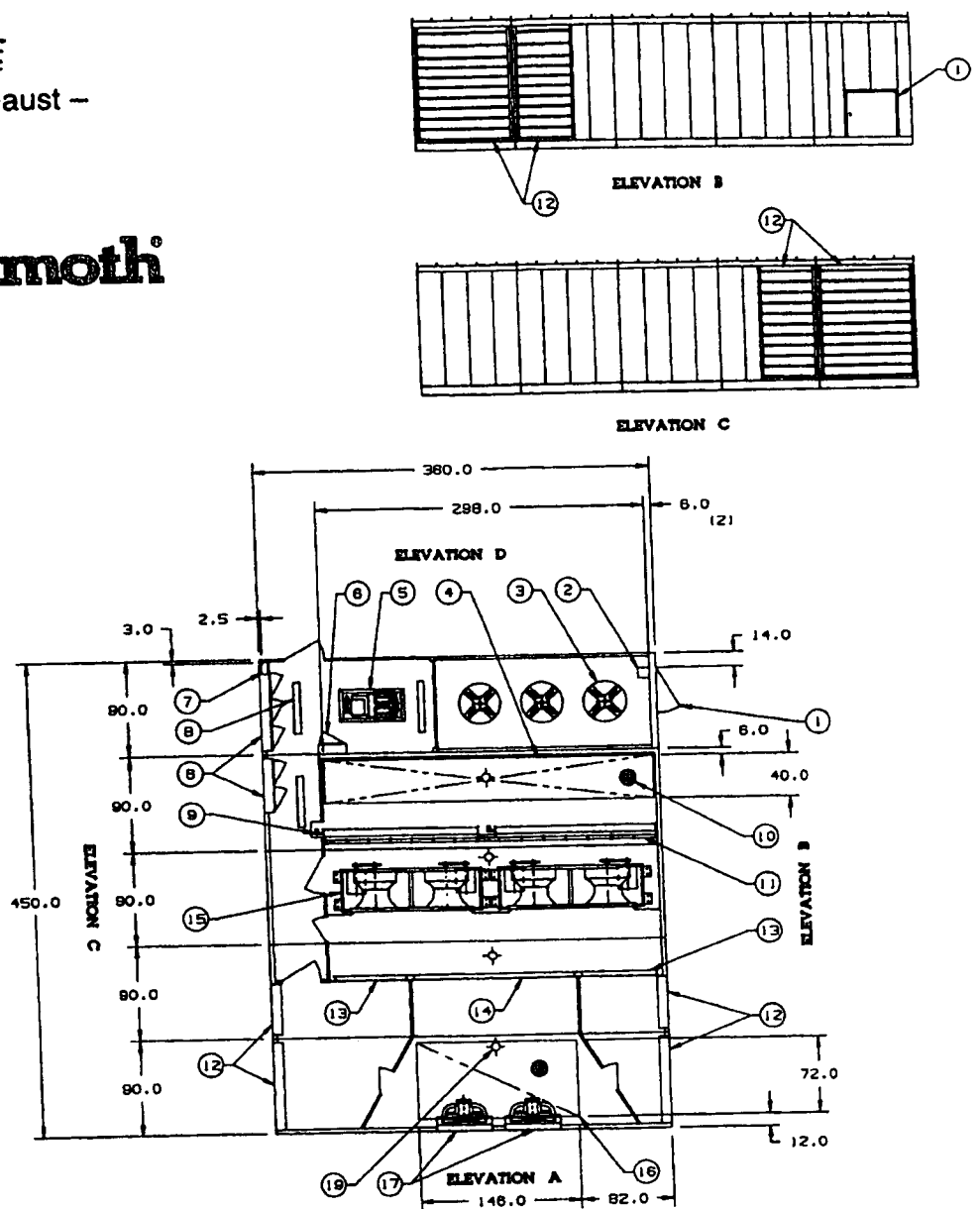




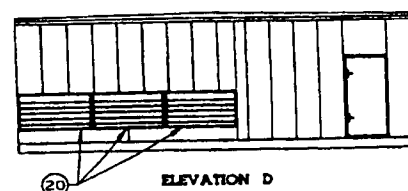
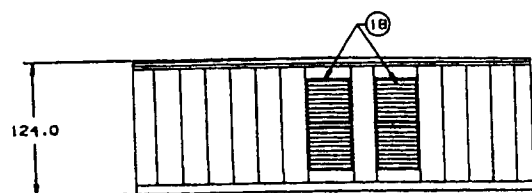
**REFERENCE**

Propeller Exhaust –  
Model 2602  
Model 3002

# Mammoth®



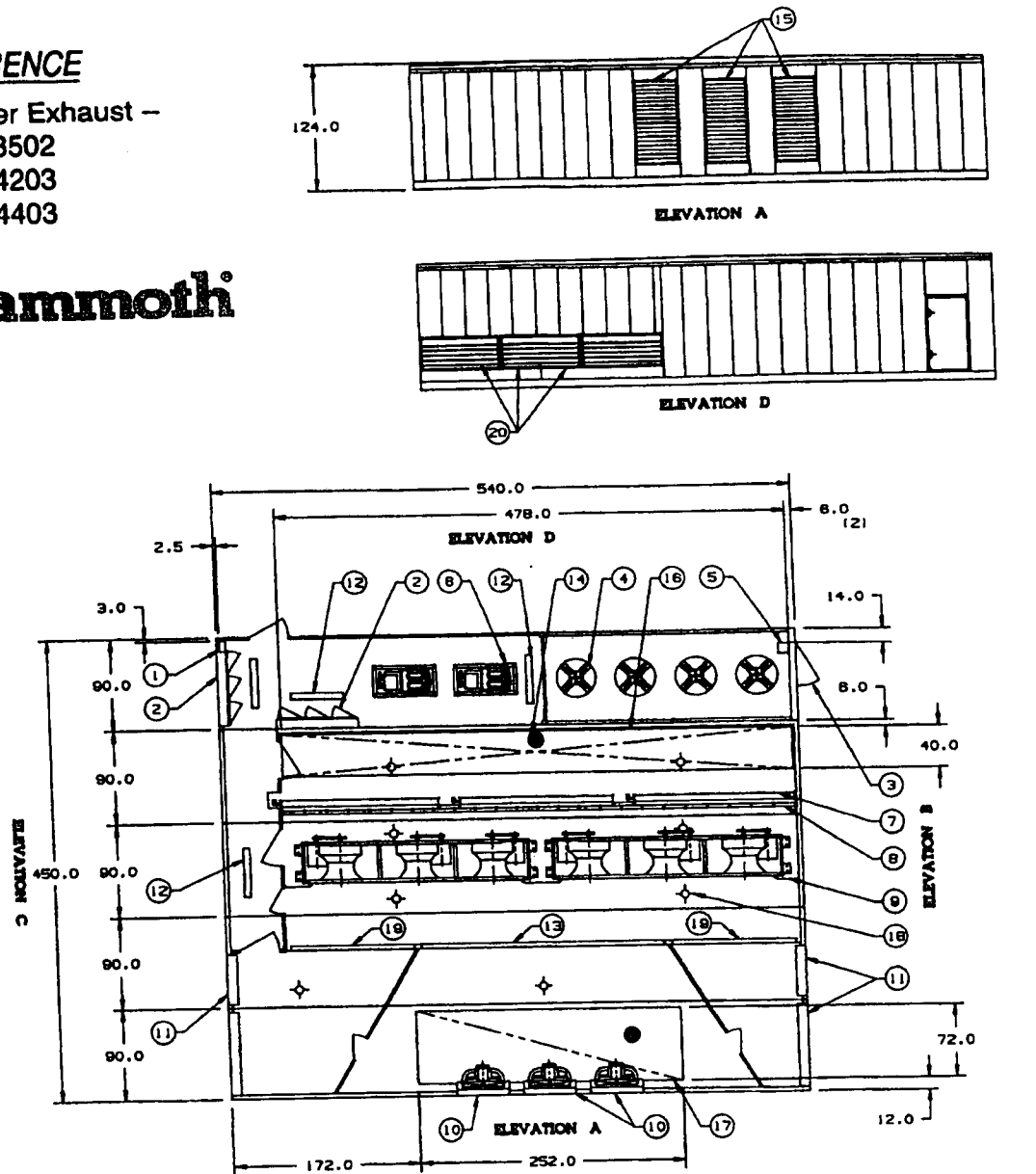
| ITEM | DESCRIPTION                            |
|------|--|
| 1    | Sump access                            |
| 2    | 10" x 10" Supply and drain water chase |
| 3    | Condenser fans                         |
| 4    | Supply opening                         |
| 5    | Compressors                            |
| 6    | Control box                            |
| 7    | 6" x 12" Electrical chase              |
| 8    | Fluorescent lights                     |
| 9    | Evaporator coils                       |
| 10   | Bar grate                              |
| 11   | 4" filters                             |
| 12   | Outside air louvers                    |
| 13   | Outside air dampers                    |
| 14   | Return air dampers                     |
| 15   | Supply fans                            |
| 16   | Return opening                         |
| 17   | Prop exhaust fans                      |
| 18   | Exhaust louvers                        |
| 19   | Incandescent vapor proof lights        |
| 20   | Sump intake                            |



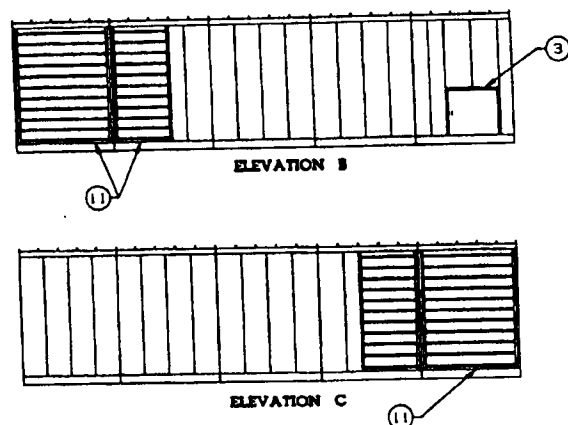
**REFERENCE**

Propeller Exhaust --  
Model 3502  
Model 4203  
Model 4403

# Mammoth



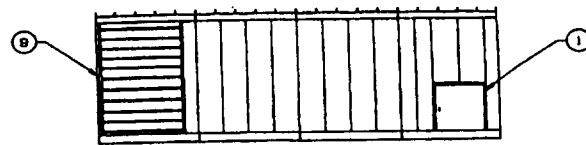
| ITEM | DESCRIPTION                            |
|------|--|
| 1    | 6" x 12" Electrical chase              |
| 2    | Control box                            |
| 3    | Sump access                            |
| 4    | Condenser fans                         |
| 5    | 10" x 10" Supply and drain water chase |
| 6    | Compressors                            |
| 7    | Evaporator coils                       |
| 8    | 4" Filters                             |
| 9    | Supply fans                            |
| 10   | Prop exhaust fans                      |
| 11   | Outside air louvers                    |
| 12   | Fluorescent lights                     |
| 13   | Return air dampers                     |
| 14   | Bar grate                              |
| 15   | Exhaust louvers                        |
| 16   | Supply opening                         |
| 17   | Return opening                         |
| 18   | Incandescent vapor proof lights        |
| 19   | Outside air dampers                    |
| 20   | Sump intake                            |



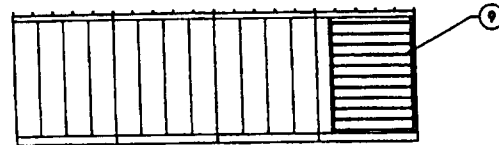
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Power Return –  
Model 2102

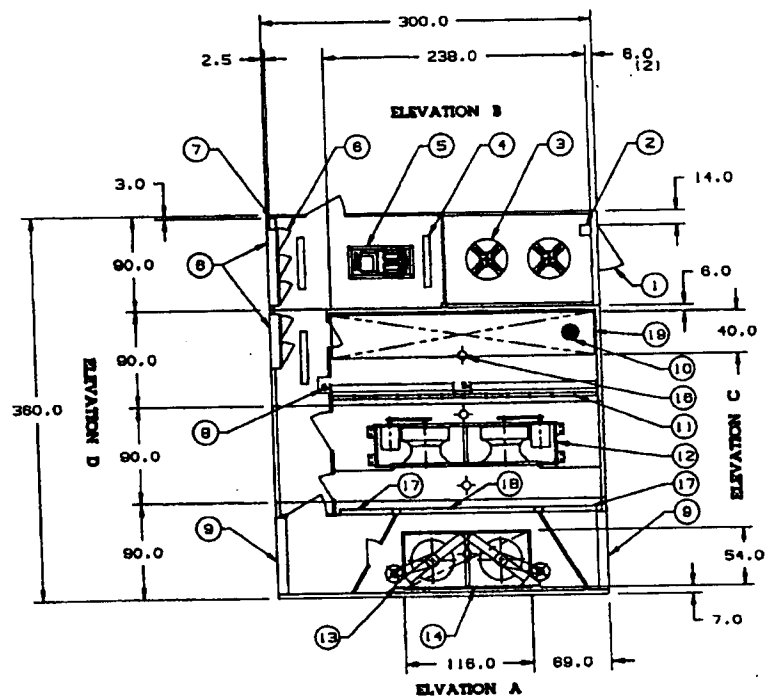
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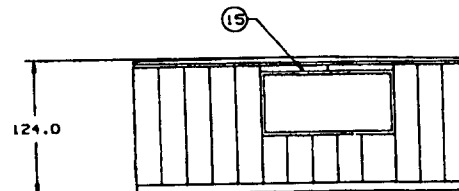
ELEVATION C



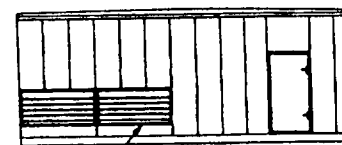
ELEVATION D



| ITEM | DESCRIPTION                            |
|------|--|
| 1    | Sump access                            |
| 2    | 10" x 10" Supply and drain water chase |
| 3    | Condenser fans                         |
| 4    | Fluorescent lights                     |
| 5    | Compressors                            |
| 6    | Control box                            |
| 7    | 6" x 12" Electrical chase              |
| 8    | Evaporator coils                       |
| 9    | Outside air louvers                    |
| 10   | Bar grate                              |
| 11   | 4" filters                             |
| 12   | Supply fans                            |
| 13   | Power return fans                      |
| 14   | Return opening                         |
| 15   | Relief panel                           |
| 16   | Incandescent vapor proof lights        |
| 17   | Outside air dampers                    |
| 18   | Return air dampers                     |
| 19   | Supply opening                         |
| 20   | Sump intake                            |



ELEVATION A

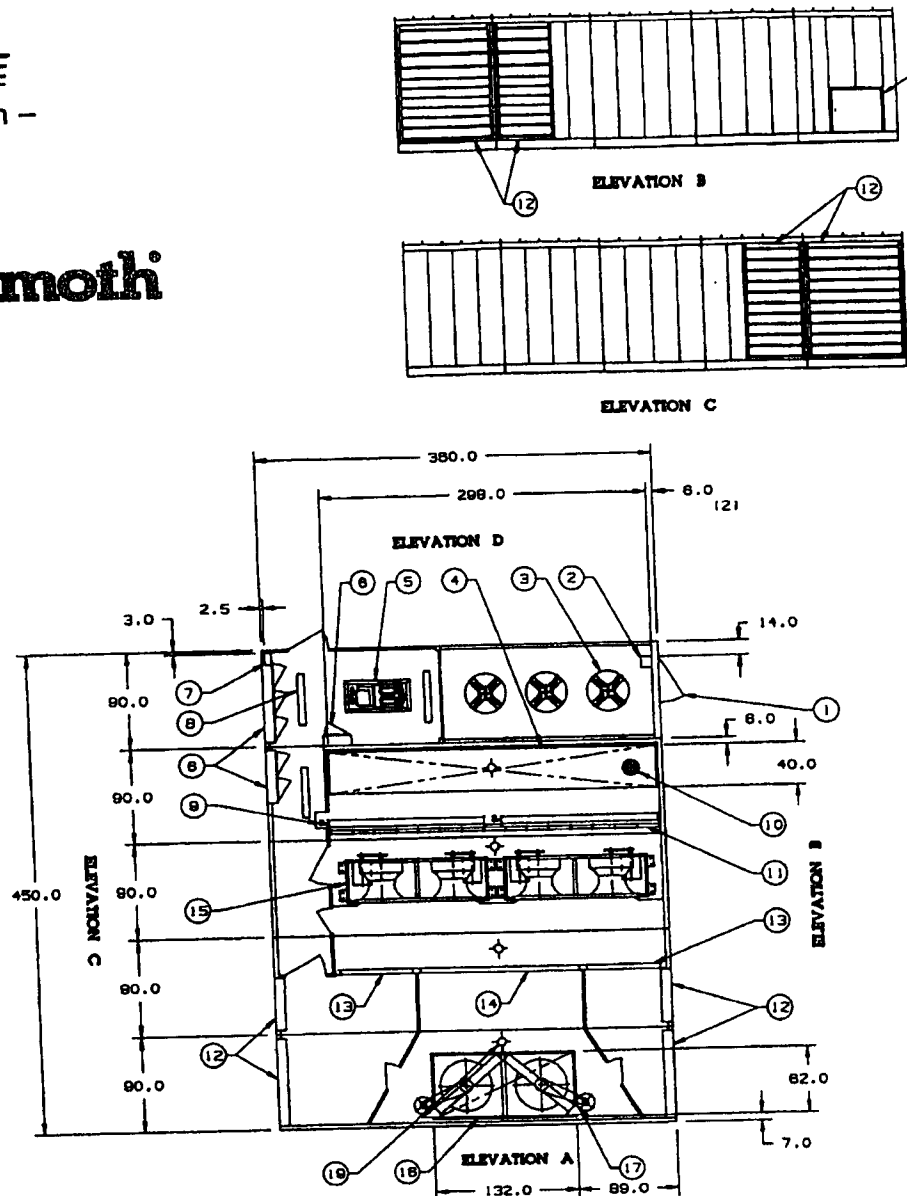


ELEVATION B

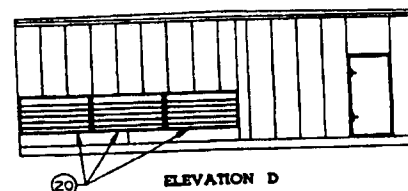
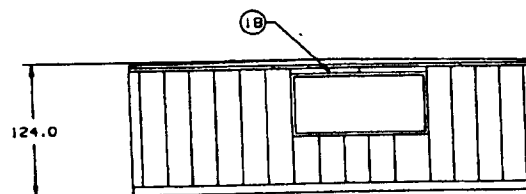
**REFERENCE**

Power Return –  
Model 2602  
Model 3002

# Mammoth

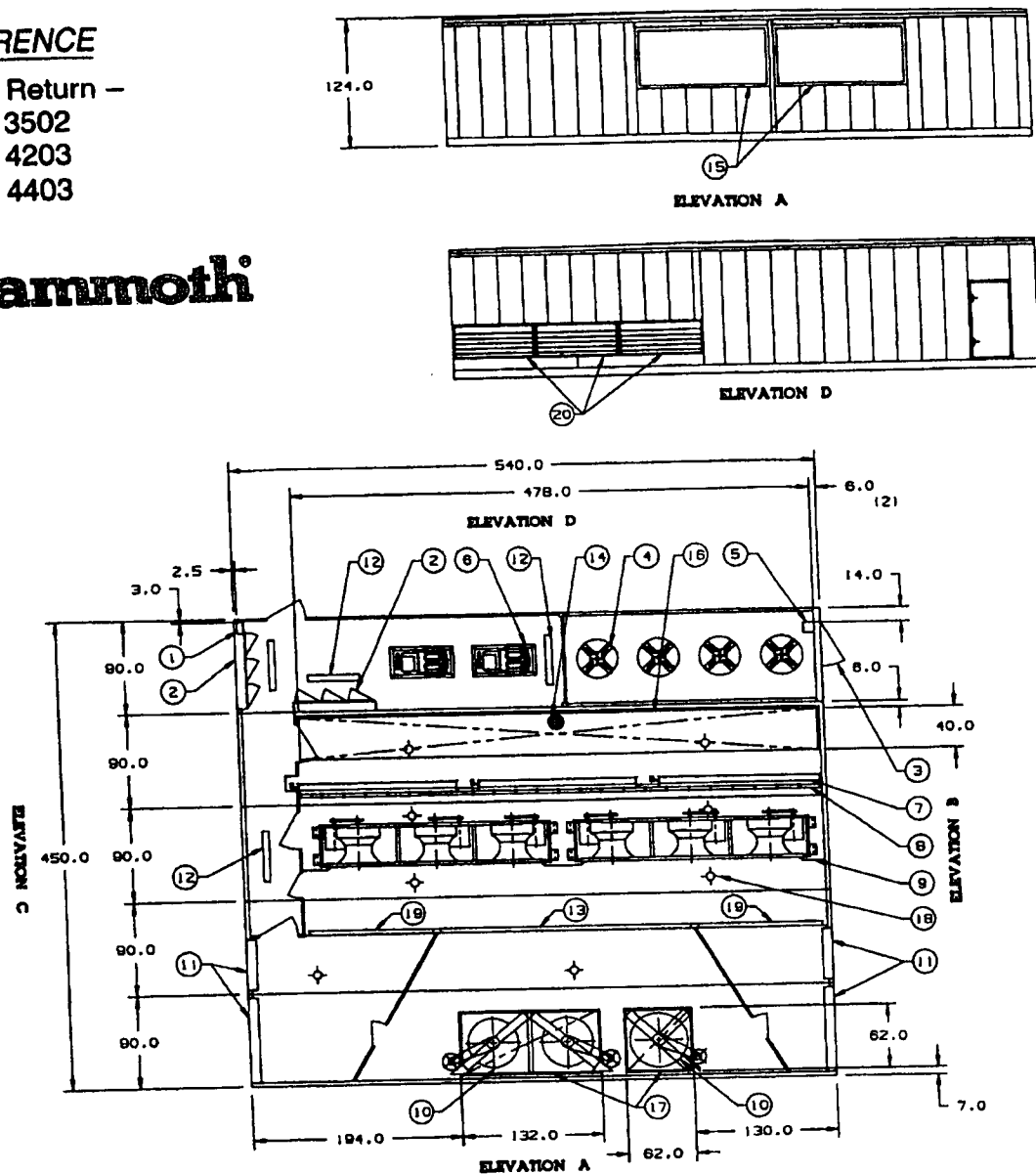


| ITEM | DESCRIPTION                            |
|------|--|
| 1    | Sump access                            |
| 2    | 10" x 10" Supply and drain water chase |
| 3    | Condenser fans                         |
| 4    | Supply opening                         |
| 5    | Compressors                            |
| 6    | Control box                            |
| 7    | 6" x 12" Electrical chase              |
| 8    | Fluorescent lights                     |
| 9    | Evaporator coils                       |
| 10   | Bar grate                              |
| 11   | 4" filters                             |
| 12   | Outside air louvers                    |
| 13   | Outside air dampers                    |
| 14   | Return air dampers                     |
| 15   | Supply fans                            |
| 16   | Return opening                         |
| 17   | Power return fans                      |
| 18   | Relief panel                           |
| 19   | Incandescent vapor proof lights        |
| 20   | Sump intake                            |

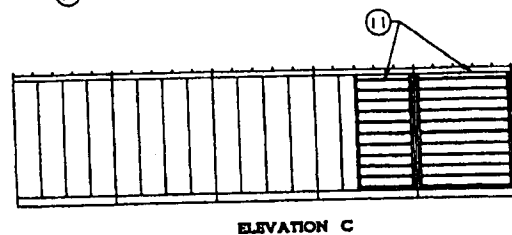
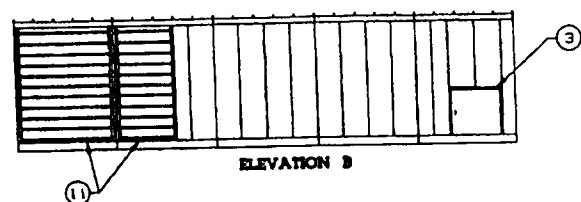


**REFERENCE**

Power Return –  
Model 3502  
Model 4203  
Model 4403

**Mammoth**

| ITEM | DESCRIPTION                            |
|------|--|
| 1    | 6" x 12" Electrical chase              |
| 2    | Control box                            |
| 3    | Sump access                            |
| 4    | Condenser fans                         |
| 5    | 10" x 10" Supply and drain water chase |
| 6    | Compressors                            |
| 7    | Evaporator coils                       |
| 8    | 4" Filters                             |
| 9    | Supply fans                            |
| 10   | Power return fans                      |
| 11   | Outside air louvers                    |
| 12   | Fluorescent lights                     |
| 13   | Return air dampers                     |
| 14   | Bar grate                              |
| 15   | Relief panel                           |
| 16   | Supply opening                         |
| 17   | Return opening                         |
| 18   | Incandescent vapor proof lights        |
| 19   | Outside air dampers                    |
| 20   | Sump intake                            |



## UNIT SPECIFICATIONS

The Penthouse unit shall be Mammoth Custom Penthouse unit of the type, size, and capacity as required and listed in the equipment schedule. Each unit shall include the pre-assembled components in accordance with the following detailed specifications.

### Construction

#### **Cabinet**

Each Penthouse unit shall be fabricated in one (1) or more sections ready for field installation. Each section shall be fabricated with a structural steel base reinforced and braced to permit the shipping and general handling of the completed section without damage to the section or internal components. The section base shall be fabricated with an 8-inch, 11.5 lb. per foot, structural member perimeter and have 8-, 11-, and 14-gauge formed structural cross members at 30" centers maximum. Additional cross members or reinforcements shall be placed at critical locations to support internal components. The base section shall have a floor of 14-gauge galvanized steel, insulated with 4-inch, 1½ lb. density fiberglass insulation and a 1/2" blanket type, dual-density construction insulation providing acoustical sound absorption capabilities. The insulation shall be retained on the underside by hardware cloth. Lifting points for the section shall be part of the section base.

The section exterior wall structure shall be fabricated of formed 11 and 14-gauge members. The exterior siding shall be 22-gauge pre-painted galvanized steel fabricated and assembled to provide an embossed exterior surface. The wall shall be insulated with 4-inch, 1½ lb. fiberglass insulation for minimum "R" value of 16.3. The interior surface of the wall shall form the air seal and shall be fabricated from 20-gauge galvanized steel. No exposed insulation shall be permitted in the air stream. Foil back or rigid board exposed stick-on insulation will not be permitted.

The top frame structure shall be fabricated of 11- and 14-gauge steel. The interior surface shall form the air seal and shall be fabricated from 20-gauge galvanized steel. The roof shall be insulated with 4-inch, 1½ lb. density fiberglass for minimum "R" value of 16.3. The roof exterior shall be constructed of 18"-wide roll-formed panel, of 24-gauge galvalume material with 2¼" standing seams. The roof shall be sloped a minimum of 2".

Sections shall be designed to be joined together by bolting through mating frame structure. The section frame shall be completely prime painted after fabrication to prevent rusting.

#### **Service Vestibule**

Each unit shall be provided with a full-height, internal walk-in service corridor. A double-wall insulated partition shall be used to separate the airflow equipment from the service corridor. The partition shall be fabricated with a 2" structural frame of 14-gauge galvanized steel, 20-gauge galvanized steel skins, and insulated with 2-inch, 1½ lb. fiberglass insulation. The service corridor floor shall be constructed of 12-gauge treadplate.

#### **Doors**

The external access door(s), and service corridor access door(s) shall be fabricated with an outer skin of 18-gauge galvanized steel, an inner skin of 20-gauge galvanized steel and insulated with 2-inch, 1½ lb. fiberglass insulation. The door shall have a continuous hinge mounted to a 12-gauge

door frame. A continuous vinyl bulb gasket shall seal between the door and frame. The access door(s) shall be secured with latches which are operable from both sides. External vestibule access door(s) shall be 36" x 75¼". Other access door(s) shall be 24" x 75¼". Internal access door(s) serving the airstream shall be provided with 6" x 6" sight ports.

### DX Cooling

#### **Compressors**

The compressors shall be of the semi-hermetic, reciprocating type, operating at no more than 1750 RPM, refrigerant gas-cooled, with three-phase inherent overload protection, with voltage available at 460-480 Volts, and "UL" listed.

Lubrication is force-fed by a self-priming reversible, gear-type oil pump to all crankcase surfaces through a fine mesh stainless steel oil strainer, with relief internal to housing conforming to ASHRAE/ANSI Code. A 350-Watt crankcase oil heater shall be supplied to maintain oil temperature during shutdown periods. Tight-seating suction and discharge stop valves are seal cap-type with pressure taps and sweat-type flanged adapters.

Capacity-reduction is accomplished by an oil pressure-actuated cylinder unloading solenoid valve located on compressor crankcase cover plate. Solenoids are controlled by Mammoth factory controls with all compressors capable of four steps of capacity control.

Compressors are tested at 330 PSI with the discharge side further tested to 450 PSI and charged with oil and R-22 to assure a sealed and dry system before final field connections are made.

#### **Evaporative Condenser**

The evaporative condenser coils shall have all prime surface staggered copper tubes, copper headers, and ABS tube sheets to allow for expansion and contraction while avoiding galvanic corrosion. A subcooler integral to the condenser coil shall provide a minimum of 10° F. liquid subcooling. The coils shall be factory leak tested at 400 PSIG nitrogen under water.

The sump shall be constructed of welded 14-gauge type 304L stainless steel below water level and 20-gauge type 430 stainless steel above water line. The sump shall be equipped with a non-mechanical electronic water level control with a brass solenoid valve in the fill line for positive shutoff. A manual 2" brass drain valve, and electric pipe heating cable shall be provided.

The water circulating pump shall be a close coupled, bronze fitted centrifugal type with mechanical seal. Pump suction and discharge lines shall have flexible connections. A type 304 stainless steel pump suction strainer shall be provided which is easily removed for cleaning. The spray header shall be PVC with non-clogging brass spray nozzles, which thoroughly wet all coil surfaces to give maximum heat transfer and minimum scaling. An automatic, factory-set, field-adjustable sump water bleed shall be provided. Units shall be factory piped and tested, ready for 1¼" supply water and 2" drain line hookup.



### **Evaporator**

The direct expansion evaporator coils shall be fabricated from staggered 1/2" O.D. x .017 wall seamless copper tubing expanded into plate-type aluminum fins to form a positive mechanical and thermal bond. The fins shall have full drawn collars to completely cover the copper tubes. They shall be factory leak tested at a minimum of 400 PSIG under water. Evaporator coils shall be provided with thermostatic expansion valves equipped with external equalizer lines and adjustable for superheat. Refrigerant shall be fed to the coil circuits by brass distributors.

Each evaporator coil shall be provided with a drain pan which shall be fabricated of galvanized sheet steel and coated with corrosion resistant mastic material, which shall be fire resistant (shall meet wet flammability per ASTM D93-73 and dry flammability per ASTM E84-70), provide vibration dampening and thermal insulation. The drain pan(s) shall extend beyond the leaving side of the coil and underneath the cooling coil connections and shall have a common threaded condensate drain connection extending through the unit base frame.

### **Refrigerant Circuits**

The refrigerant circuits shall be multiple independent circuits which shall be factory piped, tested, dehydrated and fully charged with oil and refrigerant R-22 (holding charge only). Field connections are required between sections. Each refrigerant circuit shall include liquid line service and charging valves, removable core filter drier, sight glass, liquid line solenoid valve, suction and discharge line check valves and compressor service valves.

### **Supply Air Fans**

#### **Airfoil Fans**

The fan wheels shall be multiple airfoil, single width/single inlet-SAS type, secured to a machined, ground and polished solid steel shaft. The shaft shall be coated with a rust inhibitor and shall be supported by two outboard bearings. The fan assembly shall be dynamically balanced. Bearings shall be of the self-aligning ball bearing pillow block type and shall be designed for a minimum of 200,000 hours average life. Drive shall be by means of multiple V-belts. Motor and fan assembly shall be mounted on a heavy-duty steel frame supported by springs with 1-inch deflection (2-inch deflection available).

#### **Variable Air Volume – Varlcone®**

The unit shall be capable of delivering a variable air volume by means of a conical spun-steel disk which slides through each fan inlet cone to modulate air flow from 100% open to a tight shut off. The disk is mounted on a rigid stainless steel sleeve with graphite impregnated bearings between it and the fan wheel shaft. Neither the sleeve assembly nor the control disk rotate. Position control is attained by the use of a non-binding ball-and-screw activator.

### **Outside And Return Air Dampers**

Dampers are mounted within a 14-gauge galvanized die-formed channel. The construction of the airfoil shaped blade is of extruded aluminum double wall, with a 1/2 inch, 16-gauge plated square tube axle, keyed into the 12-gauge screw compression pivot arms. Cross linkage rails are fabricated from

12-gauge galvanized 1 1/4 x 1/4 inch angle. Pivot bearings 3/4 x 3/16 inch plated steel. The axle bushings shall be injected molded from delrin. All blade edges are extruded with inflatable lip, fully operational in ambient conditions ranging from -50° F to 275° F. The leakage rate shall be 1.90 CFM at 1.0 (inches WC) to 5.2 CFM per each square foot of damper area at 4.0 (inches WC) static pressure across blade surface.

### **Outside Air Intake Louvers**

Outside air louvers shall be of a storm-proof design and shall be provided with 1/2" x 1/2" galvanized bird screen. A fully insulated divider shall be provided to separate outside air from return air.

### **Power Return/Exhaust Fans**

#### **Airfoil Fans**

The fan wheels shall be multiple airfoil, single width/single inlet-SAS type secured to a machined, ground and polished solid steel shaft. The shaft shall be coated with a rust inhibitor and shall be supported by two outboard bearings. The fan assembly shall be dynamically balanced. Bearings shall be of the self-aligning ball bearing pillow block type and shall be designed for a minimum of 200,000 hours average life. Drive shall be by means of multiple V-belts. Motors shall be heavy-duty open drip-proof, three-phase, 1800 RPM, mounted on a heavy-duty sliding base. Motor and fan assembly shall be mounted on a heavy-duty steel frame supported by springs with 1-inch deflection (2-inch deflection available). Exhaust air discharge through a non-motorized, fully-insulated gravity relief panel.

### **Propeller Exhaust Air**

Propeller exhaust fans shall each have six die-formed blades welded to a steel hub assembly. Gussets which extend three-quarters of the blade length are welded to the blades to reinforce, strengthen and prevent twisting and loss of shape under load. Each fan shall be belt-drive. Shaft bearings are pillow block type. An exhaust air non-motorized backdraft damper shall be supplied with each fan.

### **Filters**

The units shall be provided with filters installed in a galvanized steel filter rack. The filters shall be 4-inch 30% efficiency (ASHRAE 52-76 Standards) throwaway type. The filters shall be provided with easy access for insertion and removal.

### **Unit Main Disconnect Switch**

The unit shall be furnished with a molded case switch (non-automatic circuit breaker) to disconnect the power supply. The design shall incorporate a switch handle to permit unit disconnect without opening the control panel doors.



### **Main Control Panel**

The main control panel shall have an access door for direct access to the controls. The panel shall be equivalent to NEMA type 3R (rainproof) and shall contain a single, externally operated, molded case switch (non-automatic circuit breaker) suitable for copper wire up to and including 3-inch conduit. Wire and conduit entrance shall be inside of unit curbing. The main control panel shall include the following:

1. A power terminal block.
2. A power transformer with 115-Volt secondary transformer and 115-Volt circuit breakers.
3. A 24-Volt control transformer and circuit breakers.
4. Necessary relays.
5. A 115-Volt terminal strip.
6. A 24-Volt terminal strip which shall contain wired terminals for all controls, numbered in accordance with the wiring diagram.
7. An isolated 24-Volt field wiring terminal strip.
8. An electric print pocket which in addition to the electric print shall contain a pre-startup form, a startup form and maintenance instructions.

The above components shall be in addition to electrical components associated with other sections, which shall be incorporated in the main control panel to facilitate maintenance and trouble-shooting. All components shall be identified with name tags and wired in accordance with National Electric Code.

### **Temperature SST Controls, Variable Air Volume (VAV) Cooling**

Each unit shall be furnished complete with all operational controls. All controls in the basic control package shall be factory installed and wired. The control system shall be a solid state integrated system consisting of a master control sequencer, a discharge air temperature sensor, and a 24-Volt control transformer. The discharge air sensor shall have a

platinum resistance-type element which shall sense average discharge air temperature and send a ramp signal to the master control sequencer. The master control sequencer shall accept the signal and initiate stages cooling in proper sequence to maintain a constant discharge air temperature. The master control sequencer shall provide a variable time delay between cooling stages to prevent compressor short cycling.

The economizer control system shall include a modulating spring return, outside air/return air damper actuators, and an enthalpy/sensible changeover control. The enthalpy/sensible changeover control shall determine the capability of the outdoor air to provide free cooling. On a call for cooling, the master control sequencer shall modulate the economizer damper actuators to maintain the discharge air temperature at the effective set point. If this does not meet the space demand, the discharge air sensor shall cause the master control sequencer to energize the required amount of mechanical cooling. The economizer cycle shall allow only enough outside air to maintain the discharge air conditions. If the ambient conditions rise above the enthalpy/sensible changeover control set point, the economizer shall return to the minimum outside air position. The economizer shall have a minimum position potentiometer mounted in the economizer damper actuator.

### **Remote Status Panel**

A remote light indication room panel shall be supplied with each unit. The remote panel shall be supplied complete with the following:

1. Fan-on light
2. Cooling-on light
3. High head pressure failure light
4. Low suction pressure failure light
5. Oil pressure failure light
6. Service (change out) filter light

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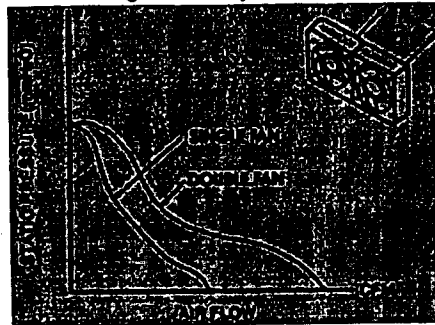
Technology

## The Parallel and Series Operation

BACK

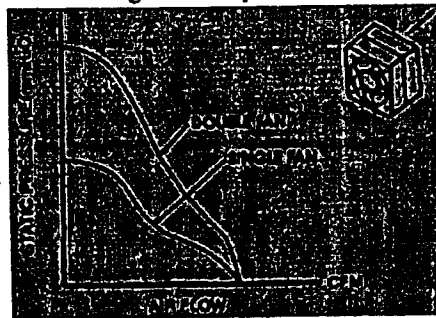
The parallel operation is defined as using two or more fans side by side.

## The Operation of Parallel Fans vs. Single Fan Graphs



@@The volume air flow of two fans in parallel will be double in the free-air condition only. If the parallel fans are applied to the higher system resistance situation, the high system resistance that enclosure has, the less increase in flow results with parallel fan operation. Thus, this type of application is only recommended for the low system resistance situation -- when the fans can operate near free delivery.

## The Performance of Series Fan vs. Single Fan Graphs



The series operation is defined as using two or more fans in series.

The static pressure capacity of two fans in series can be doubled at zero air flow condition, but do not increase the airflow in the free-air situation. An additional fan in series increases the volume flow in a higher static pressure enclosure. Thus, in series operation, the best results are achieved in systems with high resistance.

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## Series and parallel fans.

Machine Design; January 26, 1995;

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Machine Design

January 26, 1995

Using two or more fans in series or parallel may be a better alternative than a larger fan. First of all, two identical fans are usually less noisy than a single larger unit. Secondly, depending upon arrangement, either static pressure or airflow may be increased while keeping the other parameter near constant. When two fans work side by side, for example, airflow should double at free delivery. However, the higher the system impedance to flow, the lower the flow increase from the second fan. Hence, a parallel arrangement is recommended when the fans operate in low impedance near free delivery. When one fan pushes air into an enclosure and another pulls air out, the fans are in series. Best results from using fans in series are in systems with high impedance. In both series and parallel operation, especially with more than three fans, some areas of the combined performance curve are unstable and should be avoided. However, the instability is unpredictable because it res...

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## ebmpapst

### Using fans in series and parallel: performance guidelines

Ian McLeod, Engineering Director, Papst plc

When a single fan within a system cannot deliver sufficient airflow to provide the required level of cooling, and the physical size of the enclosure precludes the use of a larger fan, the concept of mounting fans in series or parallel is sometimes considered. In practice however, the only circumstances in which two fans of equal size can provide double the airflow is when they are operating in free air, i.e. no back pressure to restrict the airflow. This is a theoretical situation not found in practice.

The following article examines what really happens and how the performance of multiple fan solutions can be optimised.

Before examining the performance of series and parallel fan arrangements, it is worth considering the basic concepts of airflow characteristics in practical applications.

Fans are used to produce turbulent air currents which when forced through equipment enclosures, collect and remove heat from the internal components. Physical obstructions to this airflow not only provide a reverse pressure, which the fan must overcome, but can also mask components from the cooling air stream. The enclosure designer must therefore consider the cooling paths when the layout is being decided.

Densely packed enclosures exhibit airflow resistance, manifested as pressure loss in the direction of airflow. It's analogous to an electrical generator forcing current through a resistor - the resistor restricts the current flow.

In theory, weighting factors can be applied to determine the flow/pressure characteristics of systems. In practice, the variety of designs used in enclosures and the presence of internal cards, disk drives, power supplies or other elements that interfere with airflow, mean that it is impossible to calculate weighting factors using general formulae. Designers must rely on measurements or rough approximations.

For practical purposes, the pressure loss of an enclosure,  $\Delta p$ , is approximated by the formula:

$$\Delta p = R_v \times Q/2 \times V^2$$

where  $R_v$  is a weighting factor for pressure loss in dimensions of  $m^{-4}$ ,  $Q$  is the density of the displacement medium and  $V$  is the velocity of air flow through the system. It can be seen that pressure loss increases as the square of flow rate.

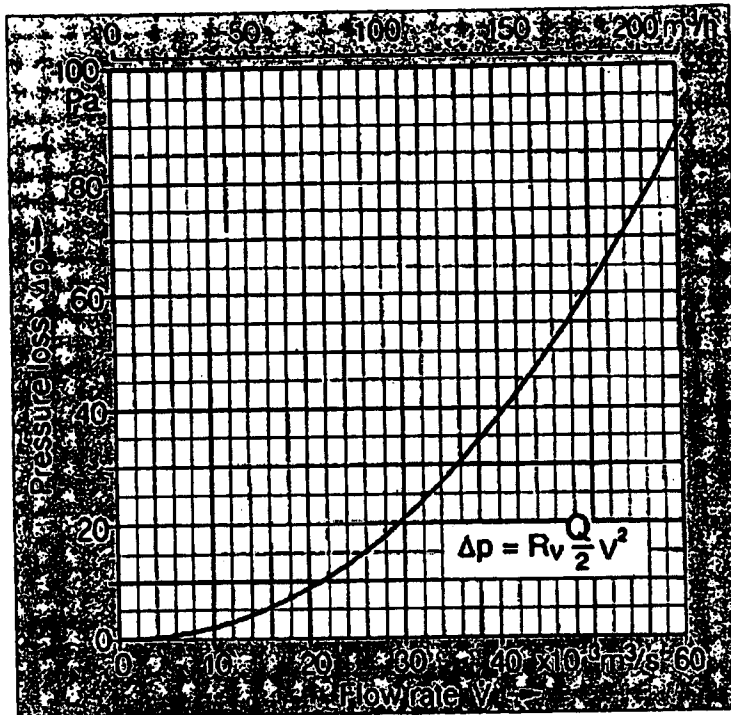
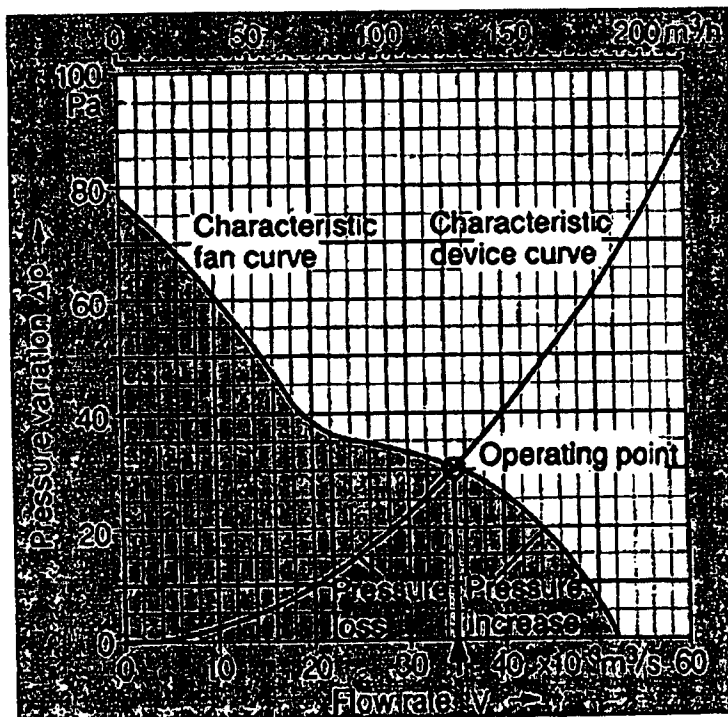


Figure 1 (above) shows the characteristic curve based on this formula where pressure loss is plotted as a function of flow rate. It describes the air flow characteristics of a given enclosure or other system.



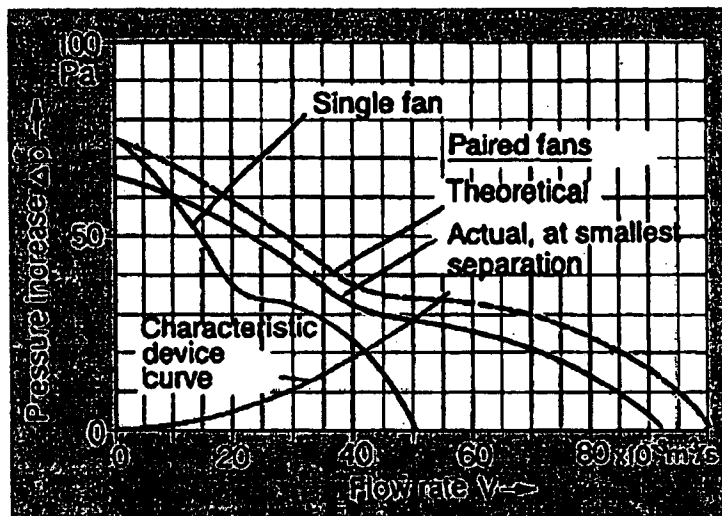
Fans operating in free air generate the maximum possible flow rates, but when fitted within an enclosure the fan is required to overcome the inherent airflow resistance. In order to achieve this the fan needs to produce a pressure increase which will in turn decrease the flow rate. A characteristic fan curve, as shown in Figure 2 (above).



expresses the relationship between flow rate and pressure.

For a given enclosure and fan, the operating point of the fan is determined by the point at which the characteristic enclosure curve and characteristic fan curve intersect. At this point, the pressure loss of the enclosure is just compensated by the pressure increase of the fan and this point determines the flow rate that is available within that enclosure.

With parallel - side by side - mounting, the flow rate is multiplied by the number of fans but the results must be plotted over the entire characteristic fan curve. If fans are placed too close together, other interference effects come into play and reduce the overall flow. This is largely because the flow of air into a fan is usually laminar and smooth, while the exhausted air is much more turbulent. Even in an ideal environment, where interference effects could be ignored, a pressure increase of four times would be needed to produce a doubling of air flow, as pressure loss increases with the square of flow rate. These differences and the effect of using fans in parallel are shown in Figure 3 (below). Here, the airflow only increases by approximately 20 to 25% over that achieved with a single fan.



When fans are mounted in series - one in front of the other - the pressure increase, in theory, is doubled. However, if the fans are close together, results will again fall short of the theoretical performance due to the angular component of airflow introduced in the exhaust of the rear fan. This limits the suction effectiveness of the front fan. One solution is to direct the angular component back into the main air current using guide vanes, but this is a rather inelegant and space-hungry solution. A more commonly adopted and balanced approach is to use one fan on the intake and one on the exhaust side of the enclosure or cabinet. The presence of internal components and the large cross-sectional area between the individual fans will mean that airflow is essentially unidirectional. This provides effective airflow and relatively low noise levels.

The choice of series or parallel fan combinations will clearly depend on the individual application. Some solutions may even require a combination of both techniques. The key point to remember is that two fans never mean twice the air flow.

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## Technical Bulletin CLEANPAK M/R/PF Multi/Redundant/Plenum Fan

The application of multiple fans in a common system, in part, provided the impetus of the design of the "plug" fan years ago. CLEANPAK International has incorporated multiple fans in common cabinets for several years to provide systems that require redundancy, to meet architectural profile requirements, and for space savings. The arrangements may be vertical up or down flow or horizontal. The notes below apply generally, but often relate to redundancy issues, which is a benefit of multiple fan operation whether a design requirement or not.

### General

There are three general arrangements for multiple plenum fan configurations as noted below. Each arrangement has its benefits.

**1+1:** 2 fans can be provided in a cabinet with either fan capable of supplying 100% of the design flow requirement. This would provide 100% redundancy. Normal operation can be simultaneous or independent.

**Twin:** 2 fans can be provided in a cabinet with both fans required for the design flow. This arrangement provides capacity in excess of 50% if a single fan fails, since the system pressure drop falls by the square root of the volume decrease. Additional capacity can be provided by ramping the VFD up to the limit of the motor full load amps. Normal operation is always simultaneous.

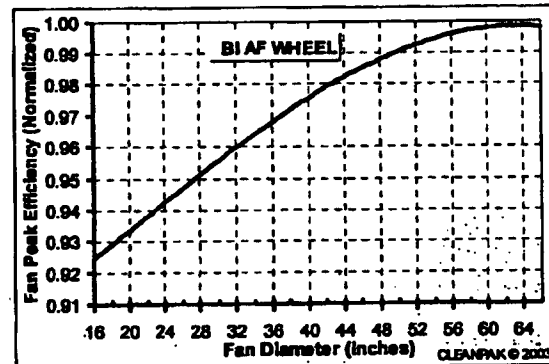
**Xn+1:** This system provides a measure of redundancy by providing a number of fans smaller than that required by the 1+1 arrangement. The failure of a single fan is accommodated by the initiation of an unused fan, or the ramp up of all remaining fans. The number of fans can be as high as 12-18, although it is not limited. Normal operation is always simultaneous.

### Airflow Isolation

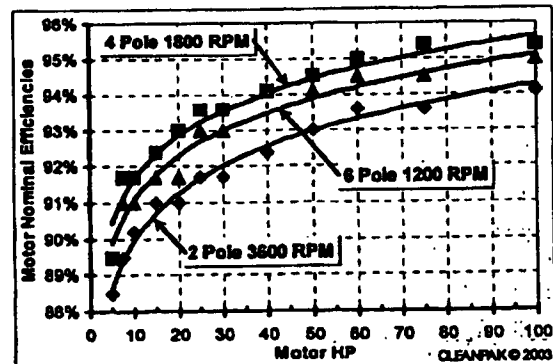
- Inlet or discharge isolation dampers with a solid dividing wall can be provided for fan service of an inoperative fan while operating at design flow for the 1+1 system. The damper pressure drop should be included in the calculation of the total static pressure (TSP).
- An Econo-Disk® may be provided for manual or automatic fan isolation for any of the applications, although as the fans become smaller (18" and under) performance penalties may result. Econo-Disk shutoff characteristics are excellent.
- Inlet isolation dampers can be provided and function similar to, but not as efficiently as, the Econo-Disk. Back draft dampers (heavy duty) can be used but may provide unstable operation at low flows. The damper pressure drop should be included in TSP calculations.
- If some sort of fan isolation is not provided, system performance will suffer a dramatic decrease with a fan failure, due to back flow through the failed fan.

### Efficiency

- Larger diameter fans have significantly higher peak efficiencies than smaller diameter fans. Selecting fans at optimum efficiency for an operating point requires the ability to vary wheel width and operating speed.
- Larger motors are significantly more efficient than smaller motors.
- Motors operated at 75% full load are slightly more efficient than those that operate at 100% full load.



Fan efficiencies are generally higher for larger size fans



Motor efficiencies are higher for larger size motors



## Technical Bulletin CLEANPAK M/R/PF Multi/Redundant/Plenum Fan

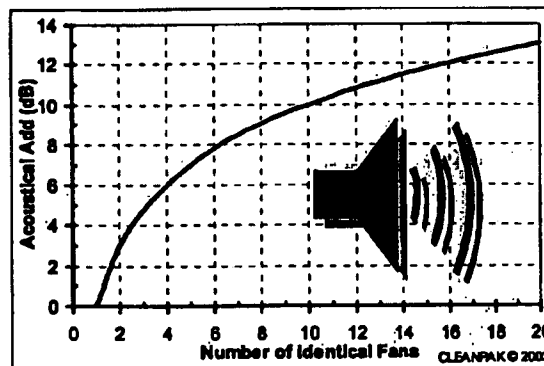
- System efficiency can be improved with internal and external pressure loss reductions such as low velocity coils and high capacity filters.

### Dimensions

- For 1+1 systems, inlet and discharge plenum lengths may depend on the normal operating condition. Multiple fan configurations allow for more even velocity profiles for any given length than a single fan configuration.
- Larger fans take more airway length than smaller fans. Service access behind fans is similar for both large and small fans.
- Isolation dampers on the fan inlet increase the airway length.
- Isolation dampers on the fan outlet increase the airway length.
- Large numbers of fans operating as in  $Xn+1$  can reduce the airway length compared to the 1+1 arrangement, particularly if the 1+1 design has an independent operating design rather than a simultaneous operating design.
- Unusual profiles may be accommodated with larger numbers of fans ( $Xn+1$ ).

### Pressure/Volume Control

- VFDs work well when the system follows the fan laws but do not work well if volume varies but the ESP is high and constant, or the fans operate with multiple volumes and constant pressure.
- The Econo-Disk can be used to provide volume control while maintaining design pressure with the simultaneous operation described in 1+1.
- Econo-Disks can be used for both volume and pressure control with manual, pneumatic, or electric actuation.
- Econo-Disks can be used with VFDs for increased flexibility and efficiency.
- Multiple fans such as  $Xn+1$  can be staged and manipulated with VFDs and isolation dampers to offer constant pressure with variable volume.
- Multiple, simultaneous operating fans are generally operated at the same speed.
- Inlet isolation dampers can be used for volume control by "riding the curve" although this is not recommended since it is an inefficient method and may result in unstable operation.



Acoustical add for multiple sources

### Sound

- Manufacturers' bare fan sound levels should be adjusted for multiple fan operation. Sound power levels are 11dB higher for 12 fans operating than for only one of the twelve.
- Smaller fans operate at higher speeds than larger fans for any given pressure. This shifts the primary tone of the fan (or blade passage frequency) to higher frequencies and may shift it to a higher octave band. Generally speaking this is advantageous in that higher frequencies are typically attenuated more easily.
- There is a potential for acoustical beats to arise with multiple fan systems.

### Vibration Isolation

- 1+1 and twin fan operations are usually internally spring isolated.
- $Xn+1$  systems with stacked fans, racked, are usually provided without internal isolation, but can be internally spring isolated.

### Service

- Smaller fans and motors are easier to physically manipulate than large fans and motors.



## Technical Bulletin CLEANPAK M/R/PF Multi/Redundant/Plenum Fan

- Larger numbers of fans, motors, VFDs, dampers, and damper actuators increase service requirements and increase the potential points of failure.
- Generally a fan will be isolated until a system shutdown for major service, or if the fans are screened service is performed while one or more fans are operating.
- Service in an active air stream, without pressure and flow interference can be performed most easily with an airlock.
- Taperlock fan hubs offer quicker and simpler motor/fan wheel replacements than straight bore hubs.
- Bearing life is unaffected by the number of fans operating (1+1 or  $Xn+1$ ), as the fewer fans use larger motors and bearings and operate at slower speeds.
- Aluminum wheels reduce the bearing load.
- Spare parts are less costly for small fans compared to larger fans.

### Electrical

- 100% redundancy systems (1+1) require greater electrical service requirements than other systems but are as efficient or more efficient during operation.
- If single VFDs are used to run multiple motors, each motor requires separate overload protection. VFD to motor lead length is the sum of all the lead lengths fed by a single VFD.
- Multiple VFDs reduce the need for VFD bypass options.

### Initial Cost

- \$/CFM are lower for larger fans.
- \$/HP are lower for larger motors and VFDs.
- Cabinet costs may be reduced with  $Xn+1$  systems, due to the reduced cabinet length.

In the application of multiple smaller fans, one should consider several factors that affect initial cost, operating efficiency, redundancy, and reliability. The discussion above should help the designer evaluate the various options. Optimizing for single or multiple fan applications calls for flexibility from the air handling unit manufacturer. Please contact CLEANPAK's technical staff for further information and assistance with your application.